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A CONTRIBUTION TO KNOWLEDGE OF THE BLOOD-SUCKING  
DIPTERA OF PALESTINE, OTHER THAN TABANIDAE.\*

By MAJOR E. E. AUSTEN, D.S.O.

(Plate IV.)

As in the case of the TABANIDAE, which have already been described,\* the material upon which the following paper is based was collected by the author during the Palestine Campaign of 1917-18.

All the specimens, including types of new species, are in the British Museum (Natural History).

Family CHIRONOMIDAE.

Sub-family CERATOPOGONINAE.

Genus **Leptoconops**, Skuse.

Syn. *Tersesthes*, Townsend.

**Leptoconops kertészi**, Kieffer.†

In abundance near Wadi Ghuzze, on Cairo road about 5 miles S.-W. of Gaza, on afternoon of 14.v.1917; settling in numbers on the faces of the writer and a companion.

*L. kertészi*, Kieffer, originally described (Ann. Mus. Nat. Hung., vi, pp. 576-577, 1908) from material taken at Cairo, and subsequently recorded by Kieffer (*op. cit.*, xvi, p. 34, 1918) as occurring in Tunisia, is already represented in the National Collection by a series of specimens from Ouargla, Algeria (*Dr. E. Hartert*), March 1912, bearing the following field-note by the collector:—"Exceedingly numerous in some of the oases south of Biskra, and very troublesome to mules." It may be added that at Bir el-Abd, Northern Sinai (50 miles E. of Kantara), 9.xii.1916, the writer met with two females of what appeared to be this species on the margin of a small salt lake, and was bitten by one of them on the arm at midday.

In life the dorsum of the abdomen of this little midge shows a double, longitudinal series of admedian, dark brown blotches, separated by neutral grey‡, triangular interspaces; the venter is whitish; the wings, the surface of which is apparently bare, are uniformly milk-white, except that in each wing the fused ends of the first and third longitudinal veins are expanded to form a kind of *stigma*, which is large and very conspicuous, and of a striking *orange* colour; the halteres are pale buff.

The suggestion by Kieffer (*op. cit.*, vi, p. 577) that *Tersesthes*, Townsend (founded for a species which attacks horses at fairly high altitudes—5,700-7,000 ft.—in New Mexico) is probably identical with *Leptoconops*, Skuse, is undoubtedly correct.

\* For Tabanidae, *cf.* the author's paper "A Contribution to Knowledge of the Tabanidae of Palestine": Bull. Ent. Res., x, pt. 3, pp. 277-321, figs. 1-18 (April 1920).

† In 1918 this species was selected by Kieffer as the type of a new genus, which he briefly characterised (Ann. Mus. Nat. Hung., xvi, p. 135, 1918) under the name *Holoconops*, relying upon the number of joints in the antenna of the ♀ to justify a generic distinction. As was recently shown, however, by Mr. H. F. Carter in his admirable "Revision of the Genus *Leptoconops*, Skuse" (Bull. Ent. Res., xii, pt. 1, pp. 1-28, June 1921), it is impossible to accord to *Holoconops* anything more than subgeneric rank.

‡ For names and illustrations of colours used for descriptive purposes in the present paper, see Ridgway, "Color Standards and Color Nomenclature" (Washington, D.C. Published by the Author, 1912).

Genus **Culicoides**, Latr.*Synoptic Table.*

The eight species described or recorded below are mutually distinguishable as follows:—

- 1 (4) Wings entirely devoid of markings.
- 2 (3) Mesonotum and crown of head olivaceous black .. .. *vitreipennis*, sp. n.
- 3 (2) Mesonotum and crown of head grey (greyish olive) .. .. *puripennis*, sp. n.
- 4 (1) Wings with markings.
- 5 (8) Pale markings on each wing (other than any that there may be at the extreme base) limited to two more or less conspicuous spots or flecks on or close to costal border.
- 6 (7) Pale wing-markings on costal border clearly defined and conspicuous; mesonotum cinnamon-coloured .. .. .. .. *tentorioides*, sp. n.
- 7 (6) Pale wing-markings on or near costal border inconspicuous, and from certain angles visible with difficulty; mesonotum dark mummy-brown  
*odiatus*, sp. n.
- 8 (5) Pale markings on each wing (other than those at the extreme base) not limited to two spots or flecks, but much more numerous and extensive.
- 9 (10) Wings each with three dark blotches on costal border, of which at least the two more distal are (as seen against a light background) conspicuously darker than those elsewhere .. .. .. .. *newsteadi*, sp. n.
- 10 (9) Wings not so marked; darker blotches on costal border (as seen against a light background) not conspicuously deeper in tint than those elsewhere.
- 11 (12) Mesonotum unicolorous .. .. .. .. *guttularis*, Kieffer.
- 12 (11) Mesonotum not unicolorous.
- 13 (14) Mesonotum with light grey markings on a dark brown ground; wings with pale spots at their distal extremities directly in contact with the wing-margin, no dark spot in contact with anterior transverse vein  
*odibilis*, sp. n.
- 14 (13) Mesonotum speckled; wings in each case with distal pale spot between rami of fourth longitudinal vein not directly in contact with wing-margin, a small but conspicuous dark spot in contact with anterior transverse vein  
*circumscriptus*, Kieffer.

***Culicoides vitreipennis*, sp. n.**

♀.—Length (one dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1 mm.; length of wing, 1.25 mm., greatest breadth of wing, 0.6 mm.

*Wings hyaline, with a milky appearance but entirely devoid of markings; crown of head and dorsum of thorax olivaceous black; legs pale.*

*Head*: vertex sparsely clothed with short, ochreous hairs, space between upper lobes of eyes with longer ochreous hairs; face and *proboscis* dark brown; inner margins of upper lobes of eyes moderately wide apart; *palpi* mummy-brown, third segment oval, moderately swollen; second segment of *antennae* (torus) mummy-brown, relatively large (larger and darker than in the following species), flagellum drab, tinged with brownish towards distal extremity, clothed with yellowish hair, first five or six segments of flagellum more or less spherical in shape, more truncate (more spherical) than in the following species. *Thorax* entirely without markings, mesonotum sparsely clothed with short, ochreous hairs; *scutellum* agreeing in coloration with remainder of dorsum, and bearing one lateral bristle on each side, also (apparently) one central bristle, as well as several short hairs. *Abdomen* (in dried condition) blackish brown, clothed at distal extremity with yellowish hairs. *Wings*

clothed (somewhat less extensively than in following species) with fine, pale, decumbent hairs (macrotrichia), wing-fringe likewise pale; costa as far as end of third vein, first and third longitudinal veins, base of fourth vein as far as anterior transverse vein and anterior transverse vein itself pale cream-buff, otherwise all veins colourless; distal extremity of third longitudinal vein curved round (not bent at an angle) to meet costa, anterior transverse vein if anything slightly shorter than in following species; both radial cells distinct, but not quite so large as in latter. *Halteres* ivory-yellow, stalks brownish at base. Legs cream-buff, femora, except at distal extremities, and tibiae, except at their bases, tinged with sepia, extreme tips of femora and extreme bases of tibiae dark brown, extreme tips of hind tibiae mummy-brown on inner side; hair on legs pale yellowish, longer hairs on outer surface of hind tibiae inconspicuous.

Near Jerisheh, 5 miles N.-E. of Jaffa, 1-8.v.1918, in author's tent at night, on lining, above lighted lamp.

The species just described is distinguishable from the European *C. pumilus*, Winn., which it resembles in size and in the coloration of the body, by the much paler wings and legs, and by the decumbent hairs (macrotrichia) on the wings being pale instead of dusky.

***Culicoides puripennis*, sp. n.**

♀.—Length (one dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1.25 mm.; length of wing, 1.4 mm., greatest breadth of wing, 0.6 mm.

*Wings* hyaline, somewhat milky, entirely devoid of markings; crown of head and dorsum of thorax deep greyish olive; legs pale.

*Head*: vertex clothed with pale yellowish hairs, face greyish sepia-coloured; *proboscis* mummy-brown; inner margins of upper lobes of eyes closely approximate; *palpi* sepia-coloured, third segment but slightly swollen, first three segments clothed mainly with dark brown or blackish hair, last two segments clothed with ochreous hair; second segment of *antennae* (torus) light sepia-coloured, paler and also somewhat smaller than in foregoing species, flagellum drab, clothed with yellowish hair, five segments following torus bluntly ovoid. *Thorax* entirely without markings, mesonotum clothed with pale yellowish hairs; *scutellum* agreeing in coloration with remainder of dorsum, and apparently bearing two central bristles and on each side two lateral bristles, as well as several short hairs. *Abdomen* (in dried condition) clove-brown, sparsely clothed with pale hairs. *Wings*: greater part of surface, except base and costal, basal and radial cells, clothed with fine, pale, decumbent hairs (macrotrichia), which at and towards distal extremity of each wing are shorter and more closely set; wing-fringe pale; costa as far as end of third vein, first and third longitudinal veins, base of fourth vein as far as anterior transverse vein and anterior transverse vein itself cream-buff (distal half of third longitudinal vein and portion of costa immediately above it somewhat darker), otherwise all veins colourless; distal extremity of third longitudinal vein bent up at an obtuse angle to meet costa, anterior transverse vein fairly long; both radial cells well developed, the first about half as long again as the second. *Halteres*: knobs straw-yellow, stalks slightly darker. Legs cream-buff or pale cinnamon-buff, distal extremities of hind femora and hind tibiae sepia-coloured, extreme tips of middle femora and tibiae tinged with brown, first joint of hind tarsi somewhat infuscated; hair on legs pale, inconspicuous.

Deirân (Rechoboth), Jaffa district, 7 miles S.-W. of Ludd, 12.iv.1918, in room at night.

From the foregoing species *C. puripennis* is distinguishable, *inter alia*, by the coloration of the dorsum of the thorax; by the second segment of the antenna being smaller and paler and the following five segments somewhat more elongate; and by the course (angulate instead of rounded) followed by the distal extremity of the third longitudinal vein.

The species just described is also allied to the European *C. albicans*, Winn., from which it may be distinguished owing to the front and middle femora and tibiae not being conspicuously tipped with blackish brown or black, and also (if Winnertz's figure—*Linnaea Entomologica*, vi, Taf. vi, fig. 35b (1852)—is to be relied upon) by the less abruptly turned up distal extremity of the third longitudinal vein.

***Culicoides tentorius*, sp. n. (Pl. iv, fig. 1).**

♂.—Length (3 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1.2 to 1.4 mm.; length of wing, 1.5 to 1.75 mm.; greatest breadth of wing, 0.6 mm.

♀.—Length (9 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1 to 1.5 mm.; length of wing, 1.4 to 1.6 mm., greatest breadth of wing, 0.75 mm.

*Dorsum of thorax* (in dried specimens) cinnamon-drab (♂, and sometimes ♀), or cinnamon-coloured (♀); *dorsum of abdomen* (in dried specimens) clove-brown or warm sepia-coloured; *wings* mouse-grey (♂), or sepia-coloured or dusky-drab (♀), an obliquely elongate area at base pale, otherwise in both sexes the only light markings are situate on costal border in shape of a pair of conspicuous ivory-yellow spots, of which that nearer the base is the larger (Pl. iv, fig. 1); *ground-colour of legs* cream-buff or cinnamon-buff, *hind tibiae in both sexes* fringed posteriorly with a row of long hairs.

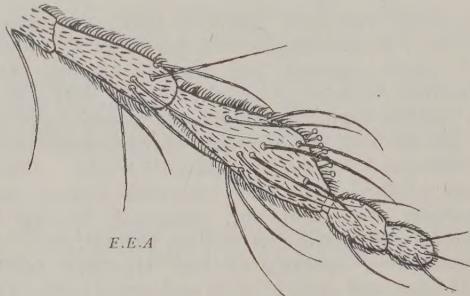
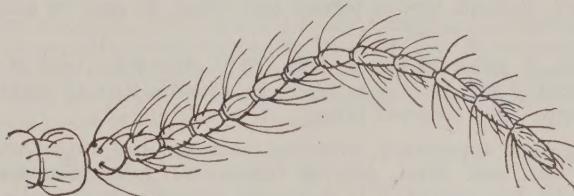


Fig. 1. *Culicoides tentorius*, sp. n.; palpus of ♀.

*Head* fawn-coloured (face cinnamon-buff), vertex infuscated (blackish-brown or deep mouse-grey) in ♂ and in both sexes clothed with curved, glistening, yellowish hairs; inner margins of upper lobes of eyes in ♀ very narrowly separated; *proboscis* and *palpi* cinnamon-buff in ♂, sepia-coloured or dark brown in ♀, palpi in ♀ clothed with brownish hair, third segment moderately swollen towards distal extremity (fig. 1); *antennae* in both sexes cream-buff or light cinnamon-buff (distal segments sometimes darker), fourth to tenth segments in ♀ moderately elongate (fig. 2), hair on antennae, including antennal plume in ♂, glistening yellowish (light ochreous or ochraceous-buff). *Thorax*: dorsum without markings in either sex, sparsely clothed with glistening ochraceous-buff hairs; *scutellum* agreeing in coloration with remainder of dorsum, and bearing in both sexes two central and two lateral bristles, as also several short hairs. *Abdomen* in both sexes clothed with pale yellowish hair. *Hypopygium* of ♂ (fig. 3): ninth sternite deeply notched in middle line; posterior

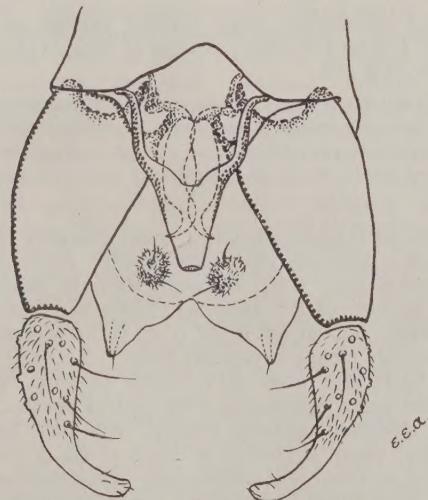
margin of ninth tergite also deeply notched, and with relatively broad finger-like extensions ; lobe-like processes of lower surface of projecting portion of ninth tergite situate some distance in front of posterior margin ; *forceps* of usual form, side-pieces each with two slender, sub-dorsal processes on inner side of proximal extremity ; proximal portion of each *harpe* with a strongly chitinised ventral process, at right angles to distal portion, distal portions of harpes noticeably broad, and each tapering



E.E.A.

Fig. 2. *Culicoides tentorius*, sp. n. ; antenna of ♀.

to a point posteriorly ; *aedoeagus* Y-shaped or lyrate, with broad, well chitinised stem, terminating bluntly behind, and with strongly chitinised limbs. *Wings* (Pl. iv, fig. 1) agreeing in both sexes as regards markings ; proximal ivory-yellow spot on costa surrounding anterior transverse vein, varying somewhat in size and outline in different individuals, but with its lower extremity reaching fold which traverses fork of fourth longitudinal vein ; proximal boundary of distal spot formed



E.E.A.

Fig. 3. *Culicoides tentorius*, sp. n. ; male hypopygium, ventral view (greatly enlarged).

by or scarcely extending beyond terminal upturned portion of third longitudinal vein ; in both sexes portions of costa and of first and third longitudinal veins between spots conspicuously darker than anything else in wing ; a larger or smaller area at base of wing pale, portions of veins included in this area, as also anterior transverse vein, upturned terminal portion of third longitudinal vein, and portions of longitudinal veins in proximal costal spot light buff or cream-buff, veins elsewhere, except as already

stated, sepia-coloured; in ♀, decumbent hairs absent from base of wing, including basal cell and costal border as far as end of first longitudinal vein, remainder of wing well clothed with these hairs, which are especially close together on costal border beyond distal costal spot. *Halteres* in both sexes cream-coloured or cream-buff. *Legs*: femora and tibiae, at least of hind legs, usually darker (tinged with mummy-brown or sepia) except at base and tip, so that these joints have a pale band at each extremity, extreme tips of femora and tibiae, at least of hind legs, often mummy-brown.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.-8.v.1918: type of ♂ and 4 ♂ para-types, type of ♀ and 10 ♀ para-types, in author's tent at night, on lining, above lighted lamp. Not observed biting.

Although in general appearance, including coloration and wing-markings, closely resembling the East and West African *Culicoides (Johannseniella) fulvithorax*, Austen, the species just described is distinguishable therefrom, *inter alia*, by its generally larger size, by the less elongate shape of the fourth to the tenth segments inclusive of the ♀ antenna, and by the fact that in the wing the distal pale spot on the costa, instead of surrounding the terminal portion of the third longitudinal vein, is only in contact with the upturned part of its extreme tip.

From the N. Italian *Culicoides susae*, Kieff., *C. tentorius* may be distinguished by its larger size, by the fourth to the ninth segments inclusive of the ♀ antenna not being globular, by the halteres being cream-buff or cream-coloured instead of white, and by the presence of a row of long hairs on the extensor surface of the hind tibiae.

#### ***Culicoides odiatus*, sp. n.**

♀.—Length (2 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1.4 to 1.5 mm.; length of wing, 1.4 to 1.5 mm., greatest breadth of wing, 0.6 to 0.8 mm.

*Dusky species, with very hairy wings, which are almost entirely devoid of markings.—Head and thorax dark mummy-brown (vertex darker), without spots or other markings; abdomen (in dried specimens) russet-brown or russet; wings with markings in each case confined to a pair of small, faint, ill-defined and inconspicuous maculae on or near costal border.*

*Head* clothed above with brownish hair; inner margins of upper lobes of *eyes* almost in contact below; *proboscis* cinnamon-brown; *palpi* dark mummy-brown, clothed with dark brown hair, third segment strongly swollen, expansion commencing immediately beyond base; *antennae* light sepia-coloured, agreeing closely with those of *C. tentorius*, Austen (*cf. fig 2, p. 111*) as regards shape of segments, and clothed with yellowish (ochraceous-buff) hairs. *Thorax*: mesonotum clothed with ochraceous-buff hairs and with dark brown bristles; *scutellum* bearing, in addition to several short hairs, apparently four central bristles, as also on each side two lateral bristles. *Abdomen* sparsely clothed with pale hairs, except on sides and at distal extremity, where a portion at least of the hairs are dark brownish. *Wings*: with exception of basal and costal cells, practically entire surface clothed with long, closely set, decumbent hairs, which, especially in region beyond level of end of third longitudinal vein, where they are thickest, largely overlap one another; of the two faint pale maculae in each wing, that nearer the base surrounds the anterior transverse vein and extends only indistinctly to the costa, the other is situate on and adjacent to the costa at the end of the third longitudinal vein, the extreme tip of which it includes; second radial cell much broader than the other, which is practically obliterated and indistinguishable. *Halteres* cream-buff, distal extremities of stalks greyish. *Legs*: femora light sépia-coloured (hind pair darker), in each case with a faintly marked pale band (less conspicuous in that of hind pair) before extreme tip.

which is infuscated; tibiae drab-coloured or brownish drab, their extreme tips infuscated; tarsi light ochraceous-buff; tibiae clothed with brownish or yellowish hair, a series of long hairs on extensor surface of hind pair; upper surface of hind tarsi clothed with fairly long, pale hair.

Near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.-8.v.1918: type and one para-type, in author's tent at night, on lining, above lighted lamp.

The species described above is allied to the foregoing (*C. tentorius*, Austen), but, in the ♀ sex at any rate, is distinguishable *inter alia* by the more swollen third joint of the palpi, by the much darker colour of the dorsum of the thorax, by the wings being much more hairy, and by the two pale spots on the costal border being only faintly indicated and much less developed.

***Culicoides newsteadi*, sp. n. (Pl. iv, fig. 3).**

♀.—Length (3 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1.2 mm.; length of wing, 1.3 mm., greatest breadth of wing, 0.6 mm.

*Allied to the European C. pulicaris, L., and agreeing therewith in wing-markings in case of specimens in which pattern shown in Pl. iv, fig. 3 is somewhat reduced, but, in ♀ sex at any rate, distinguishable inter alia by much smaller size, and by presence of a pale band, sharply defined in case of fully-coloured specimens when viewed against a dark background, at distal extremity as well as at base of hind tibiae.*

*Head*: vertex sparsely clothed with curved, yellowish hairs; inner margins of upper lobes of eyes in contact or separated by an exceedingly narrow interval; *proboscis* dark brown; *palpi* sepia-coloured, clothed partly with brownish, partly with yellowish hair, third segment strongly swollen; *antennae* light sepia-coloured or light mummy-brown, third to tenth segments inclusive generally paler (cream-coloured), hair on antennae yellowish. *Thorax*: dorsum clothed with shining ochraceous-buff hairs, ground-colour (in dried specimens) olive-grey, with a mummy-brown area on each side anteriorly, or light greyish olive, with anteriorly a narrow, sepia-coloured, longitudinal streak in middle line, becoming obsolete towards hind margin, and on each side, between it and lateral border, a broader and longer, curved, longitudinal stripe of same colour; *scutellum* agreeing in ground-colour with remainder of dorsum, and bearing two central and two lateral bristles, as also three short hairs between each central and corresponding lateral bristle. *Abdomen* sparsely clothed with pale (cream- or cream-buff-coloured) hairs. *Wings*: in specimens with fully-developed wing-markings, latter are as shown in Pl. iv, fig. 3, the three dark blotches on costal border dark mouse-grey and very conspicuous, remaining dark markings mouse-grey; in many specimens, however, mouse-grey markings between costal border and hind margin are much reduced in extent, taking form of partly discontinuous and isolated spots and flecks; greater part of distal half of wing-surface, as well as of hind border, fairly thickly clothed with decumbent hairs. *Halteres*: stalks cream-coloured, knobs ivory-yellow. *Legs* sepia-coloured or light sepia-coloured, tarsi, middle and hind knees, and a band at each extremity of hind tibiae paler (pinkish-buff or pale pinkish-buff—in well-coloured specimens pale bands on hind tibiae are cinnamon-buff); hair on legs pale, hind tibiae on outer surface with a row of long hairs.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.-8.v.1918: type and 5 para-types, in author's tent at night, on lining, above lighted lamp: dedicated, as a trifling token of sincere regard, to Robert Newstead, F.R.S., Dutton Memorial Professor of Entomology, Liverpool School of Tropical Medicine. Although not actually taken *in flagrante delicto*, there can be no doubt that this species is a blood-sucker, since in the case of the type fresh blood was observed in the abdomen at the time of capture.

A ♂ *Culicoides* taken, with specimens of four other species of the same genus, at Sheikh Zowaaid, N. Sinai, 14.iii.1917, in the author's tent at night, and almost certainly belonging to the species just described, measures (in the dried condition) 1.6 mm. in length from the anterior margin of the thorax to the posterior extremity of the abdomen. In the *genitalia*, the side-pieces (basal portions of forceps) are considerably less swollen than in the case of *C. pulicaris*, L., ♂, so that the disparity in size between these and the claspers is not so great. As regards *wing-markings*, with the exception of the distal costal blotch, which is undiminished, all the dark markings are much reduced, those other than on the costal border appearing as some eight or nine faint and almost completely isolated flecks.

***Culicoides guttularis*, Kieff.**

*Culicoides guttularis*, Kieffer, Ann. Mus. Nat. Hung., xvii, p. 45 (1919).

Three ♀♀, near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.-8.v.1918, in author's tent at night, on lining, above lighted lamp. Not observed biting, but one of the three specimens brought back has its abdomen distended, apparently with blood.

*C. guttularis*, the type of which was taken in Hungary (Budapest), also occurs in Great Britain, and has been taken in Middlesex, Herts, Huntingdonshire and the Isle of Arran. The specimens obtained in Palestine differ from the typical form, as described by Kieffer, and agree with British examples, in having a dark transverse mark across the centre of the axillary cell, the distal extremity of which, in contact with the posterior branch of the fifth longitudinal vein, is also infuscated.

***Culicoides odibilis*, sp. n. (Pl. iv, fig. 2).**

♂.—Length (1 dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1.25 mm.; length of wing, 1.5 mm., greatest breadth of wing, 0.6 mm.

*Antennal plume cream-buff (looking brownish in certain aspects, or when the hairs are matted together); dorsum of thorax dark brown, with conspicuous light grey markings; wings infuscated and iridescent, with sharply defined milk-white or cream-coloured spots, as shown in Pl. iv, fig. 2.*

*Head*: *proboscis* and *palpi* mummy-brown, clothed with dusky hairs; *torus of antenna* blackish brown, third to twelfth segments inclusive ivory-yellow or almost colourless, last three segments sepia-coloured in certain lights, clothed with dusky hairs mixed with some pale hairs. *Thorax* dark mummy-brown, mesonotum sparsely clothed with glistening yellowish hairs, and with ground-colour varied by conspicuous and sharply defined light neutral grey markings, chief among which are a sinuous mark, shaped something like a note of interrogation (?), embracing each anterior slit-like depression, a small spot behind each of these marks, a transverse row of four transversely elongate spots across the middle, and a broad, somewhat trident-shaped mark on hind border; base and sides of *scutellum* light neutral grey. *Abdomen* dark neutral grey (claspers paler—light brownish olive), clothed with dusky hair, paler (yellowish) towards the tips. *Hypopygium*: ninth sternite deeply emarginate; posterior margin of ninth tergite not noticeably notched in middle line, finger-like extensions narrower than in *C. guttularis*, Kieff.; lobe-like processes of lower surface of projecting portion of ninth tergite situate some distance in front of posterior margin; *forceps* of usual form, but claspers less elongate than in *C. guttularis*, and their distal extremities not swollen as in the latter species; *harpes* broad, with distal extremity of each attenuate and elongate; limbs of *aedeagus* strongly chitinised and forming a Y-shaped or lyrate rather than a U-shaped figure, as in *C. guttularis*, stem of *aedeagus* moderately broad, apparently rather short, fairly well chitinised and ending bluntly behind. *Wings* (Pl. iv, fig. 2) deep mouse-grey, with a strongly

developed purplish iridescent sheen, and with sharply defined, spot-like, milk-white or cream-coloured markings, chiefly along distal and posterior borders, as shown in figure; hind border of axillary cell to level of axillary angle, and greater part of distal half of each wing fairly thickly clothed with decumbent hairs, which as usual are especially close together on distal third, particularly in area beyond distal costal spot. *Halteres*: knobs straw-yellow, stalks cream-coloured. *Legs*: femora and tibiae light sepia-coloured (hind femora somewhat darker), knees (tips of femora and extreme bases of tibiae) and tips of hind tibiae mummy-brown; tarsi, extreme bases of all femora, a ring immediately before tips of front and middle femora, and a similar ring immediately beyond bases of all tibiae and before tips of hind tibiae cream-coloured; hind femora with a faint indication of a narrow pale ring before tips; hind tibiae with a row of long, dusky hairs on extensor surface, hair on tarsi and on flexor surface of hind tibiae pale.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.1918; in author's tent at night, on lining, above lighted lamp.

*Culicoides odibilis* is allied to the foregoing species (*C. guttularis*, Kieff.), from which however it is readily distinguishable by the neutral grey markings on the dorsum of the thorax, by the differences in the ♂ hypopygium detailed above, and by the much more sharply defined wing-markings, in which the pale spots are considerably less extensive.

***Culicoides circumscriptus*, Kieff.**

*Culicoides circumscriptus*, Kieffer, Ann. Mus. Nat. Hung., xvi, p. 49, fig. 15 (1918).

One ♀, near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.1918, in author's tent at night, on lining, above lighted lamp.

The specimen referred to agrees on the whole very well with Kieffer's description of the species, the type of which was obtained in Tunis. The inner margins of the upper lobes of the eyes, though separated above by a space, the width of which is approximately equal to that of the flagellum of the antenna, are closely approximate below. In the much bespotted wings, practically the entire surface of which is thickly clothed with decumbent hairs, the dark fleck (alluded to by Kieffer) enclosed in the proximal pale costal blotch is situate immediately beyond, and in contact with, the anterior transverse vein, occupying the angle formed by the latter and the praefurcal portion of the fourth longitudinal vein; a small pale fleck inside the fork of the fourth vein, close to its base, is not mentioned by Kieffer.

*Note*.—In an addendum to a short paper by E. Brunetti on "Some Noxious Diptera from Galilee" (Journ. Asiatic Soc. Bengal, New Ser., ix, pp. 43-35, 1913), Dr. N. Annandale writes (*loc. cit.*, p. 45):—"Another irritating blood-sucker common at Tiberias in October, though much less so than *Ph. papatasi*, is a minute Chironomid of the sub-family Ceratopogoninae. Like *Phlebotomus* it is nocturnal in its habits." On p. 370 of Vol. x of the same journal (1914), in a note to Kieffer's description of *Trichotanypus tiberiadis*, Kieff., Dr. Annandale remarks:—"This is the species I referred to in a note on a former paper (J. A. S. B. (n.s.), ix, p. 45, 1913) as being a troublesome bloodsucker at Tiberias." There would appear to be some confusion here, since the genus *Trichotanypus* does not belong to the CERATOPOGONINAE, and the species included in it are structurally incapable of sucking blood.

Genus ***Forcipomyia*, (Mg.) Kieffer.\***

***Forcipomyia* (?) *bipunctata*, L. var.**

One ♂, Mount of Olives, 1.vii.1918, in Kaiserin Auguste-Viktoria Stiftung, on window.

\* No species of this genus is actually known to suck blood.

The only obvious differences from British examples of *F. bipunctata*, L., exhibited by the above specimen are that the hair on the scutellum is paler and perhaps longer, that clothing the distal extremity of the abdomen paler, and that covering the wings apparently shorter, while the knobs of the halteres are dead white without a tinge of yellow.

### Family CULICIDAE.

Of the mosquitos collected and bred by the author during 1917-18, a considerable number were subsequently destroyed by Psocids. The material actually brought home includes representatives of 20 species, all but two of which, however, have already been recorded from various localities in Palestine by Captain P. J. Barraud, in a paper published by him in this Bulletin a few months ago.\* It will therefore suffice to mention the additions† to Captain Barraud's list, which both belong to the genus *Culex*, and are as follows.

#### **Culex tritaeniorhynchus**, Giles.

One ♀, bred, 9.viii.1918, from larva in floating débris : R. Auja, Khirbet Hadrah, 6 miles N.-E. of Jaffa.

#### **Culex modestus**, Fic.

Two ♀♀, bred, 14.20.v.1918, from larvae in marsh at Tel Abu Zeitun, near Jerisheh, 5 miles N.-E. of Jaffa.

It may be added that bionomical notes on various species of *Anopheles* will be found in the author's paper entitled "Anti-Mosquito Measures in Palestine during the Campaigns of 1917-1918,"‡ although it now appears that in certain cases the nomenclature there used is in need of revision. Thus—

*A. maculipennis*, Mg., should be *A. maculipennis*, Mg. var.

*A. sinensis*, Wied., should be *A. hyrcanus*, Pall.

*A. palestinensis*, Theob., should be *A. superpictus*, Grassi.

*A. turkhudi*, Liston, should be *A. multicolor*, Camb.

### Family SIMULIIDAE.

#### Genus **Simulium**, Latr.

#### **Simulium flavipes**, sp. n.

♂.—Length (4 specimens), 2 mm.

Black; anterior border of dorsum of thorax with a pale neutral grey patch on each side, a similar patch on hind border in front of scutellum; antennae vinaceous cinnamon or light pinkish cinnamon; genitalia indistinguishable from those of *S. angustitarsis*, Lundstr.§; legs Naples yellow or pale buff yellow, tarsi, tips of tibiae and of hind femora mummy-brown or sepia-coloured, front tarsi slender, not at all expanded, first joint of hind tarsi strongly incrassate.

Head: palpi mummy-brown. Thorax: front border of dorsum clothed with minute, appressed, glistening yellowish hairs; meso- and sternopleurae neutral grey or light neutral grey. Abdomen: hair on abdominal scale pale yellowish. Halteres cream-coloured. Legs: front and middle coxae (at least in some specimens)

\* "Mosquitos Collected in Palestine and Adjacent Territories," by Captain P. J. Barraud, F.Z.S., F.E.S. : Bull. Ent. Res., xi, pt. 4, pp. 387-395 (March 1921).

† For the identifications of these the author has to thank Mr. F. W. Edwards.

‡ Trans. Soc. Trop. Med. and Hygiene, xiii, no. 4, pp. 47-60 (November 1919).

§ Figured by Edwards, Bull. Ent. Res., vi, pt. 1, p. 24, fig. 1, i (June 1915), as those of "S. aureum."

with a dark brown or blackish spot or streak on posterior surface; middle femora with extreme tips light mummy-brown on upper surface; hind legs clothed with fine yellowish hair (tips of tarsi with brownish hair); hind tibiae strongly expanded towards distal extremities; last four joints of front tarsi together approximately equal in length to, or slightly longer than first joint; first joint of hind tarsi somewhat lighter towards base, second joint short but *without any noticeable dorsal excision*, combined length of last four joints of hind tarsi equal to slightly more than half length of first joint.

Wadi el Kelt, Jordan Valley, near Jericho: type and three para-types, 1.vi.1918, forming part of a number of ♂♂ of same species, dancing in small swarms in dry portion of Wadi bed, 5.30-6.30 p.m. At the same time ♀♀ of *Simulium equinum*, L. (see below), were abundant in the ears of horses picketed close by, on top of the Wadi bank.

The species just described is allied to the Algerian *Simulium beckeri*, Roubaud (Bull. Mus. d'Hist. Nat., xii, p. 520, 1906), but is apparently distinguishable, *inter alia*, by its somewhat larger size, and by the leg markings, e.g., by the presence of dark brown or brownish tips to the front and middle tibiae, and by the proximal extremity of the hind tibiae being entirely yellowish (*i.e.*, without a blackish ring at the base). *Simulium flavipes* is also closely allied to an undetermined Ethiopian species (represented in the National Collection by five specimens from Zomba, Nyasaland Protectorate), in which, however, the dark markings of the femora and tibiae are more strongly developed.

### **Simulium equinum, L.\***

Seven ♂♂, Tel Abu Zeitun, near Jerisheh, 5 miles N.-E. of Jaffa, 2.v.1918—part of small swarm dancing at foot of the Tel, near the marsh, 6.15 p.m.; 3 ♀♀, Jericho Plain, 15.iv.1918, “biting horses' ears in morning and evening, all over the Plain” (*Captain Kendle, Australian Veterinary Corps*); 12 ♀♀, Jericho Plain, 19.iv.1918, “in large numbers, attacking insides of horses' ears”; 1 ♀, Hadrah Dam, R. Auja, 29.iv.1918, “flying low over the water, apparently ovipositing on green slime close to the water's edge, 6.15 p.m.”; 1 ♀ (pale-legged variety), Jericho Plain, near Wadi el Kelt, 31.v.1918, “in horse's ear in evening.”

In the Wadi Hamis, near Ain Kanieh (about 11 miles N.N.-W. of Jerusalem), on 8.iii.1918, at a spot where the shallow water was flowing very swiftly, a greenish *Simulium* larva was present in myriads on the stones in the bed of the stream. No adults were seen, and under the circumstances it was impossible to attempt to breed out any of the larvae. Close to the spot referred to, a number of *Simulium* larvae, apparently belonging to three different species, were also found on the leaves of a submerged piece of reed. Some of these latter larvae were collected and taken back to quarters, and although the majority of those brought back died within two days, two were observed on 10.iii.1918 to have pupated. One of the pupae (examined and sketched as well as possible with the aid of an ordinary platyscopic lens) was found to have on each side six slender respiratory filaments, apparently arising separately from what looked like a long, narrow, whitish pad, the whole arrangement, except as regards the thinness and length of the filaments, being similar to that of the pupal respiratory organs of *S. equinum*, L., as recently figured by Edwards.†

On 19.iv.1918 in the Wadi el Aujah (6½ miles N. of Jericho), a rushing stream of about five yards in width, *Simulium* larvae were abundant on the stones. In fact, just as in the Wadi Hamis six weeks earlier, so numerous were the larvae on some of the stones that the latter looked as though they were hairy.

\* For the definite determination of this species, the writer is indebted to Mr. F. W. Edwards.

† F. W. Edwards, Bull. Ent. Res., xi, pt. 3, p. 236, fig. 6 (December 1920).

At Hadrah Dam, R. Auja, on 29.iv.1918, when, as already recorded, a ♀ of *S. equinum* was taken apparently ovipositing, the stones in the bed of one of the sluices were seen to have numerous small *Simulium* larvae on them.

No adults of *Simulium* were observed in Palestine in 1917, but on 9th June in that year larvae were found on stones in running water in the Wadi Shanag (the upper part of the Wadi Ghuzze), at Bir Esani, by Lt.-Col. Richardson, D.S.O., R.A.M.C. Similarly, in the Wadi Ghuzze itself near Tel el Fara, in a rapidly flowing channel issuing from a pool, the writer noticed a few *Simulium* larvae on stones, on 31st July 1917. There can be little doubt that several species of *Simulium*, in addition to the two recorded above, occur in Palestine, and that the genus will be found to exist wherever the presence of running water affords the conditions necessary for breeding.

#### Family PSYCHODIDAE.

##### Genus **Phlebotomus**, Rond.

###### **Phlebotomus papatasii**, Scop.

Probably abundant during the hotter months in every town and village in Palestine, besides being widely distributed in the open country.

The small amount of material of this species which the author succeeded in bringing home in safety consists of:—2 ♂♂, 4 ♀♀, Deir el Belah, 8 miles S.-W. of Gaza, 13.viii.1917, in corners of an "E.P." tent, 10.30 a.m.; 1 ♀ (abdomen distended by eggs), Deir el Belah, 22.viii.1917, in circular tent (alongside earth bank surmounted by cactus hedge) in which a case of "sand-fly (*Phlebotomus*) fever" had occurred; 1 ♀, Deir el Belah, 8.ix.1917—both sexes numerous in upper corners of E.P. tent, used as office by 14th Coy. (A.T.) R.E., in palm grove at No. 14 Well; 2 ♂♂, 2 ♀♀, Bir ez Zeit (13 miles N. of Jerusalem), 22.vii.1918, in house—at least 5 ♀♀ seen in dark, cellar-like basement of one house, and a number more specimens of both sexes (one ♀ full of partly digested blood) in a dark, open cupboard in a room on first floor of another dwelling; 1 ♀, Et Tireh (about 5 miles N.N.-E. of Ludd), in corner of dark granary; 1 ♀, Mulebbis, 2.viii.1918—with another specimen, in corner of packing shed at orange grove.

More than one of the females enumerated above, which has the wing fringes, especially those on the costal margins, decidedly dark, apparently belongs to Newstead's "Dark form."\*

In July and August 1917, the occurrence of a number of cases of sand-fly fever in the E.E.F. at Deir el-Belah caused attention to be directed to *Ph. papatasii*, which was at that time common in many places in dug-outs and tents, in the case of the latter, especially such as were pitched in the palm groves near the wells or close to banks of earth crowned with cactus hedges. Efforts to find breeding places failed, though possibly lizard holes, more particularly the burrows of *Agama stellio*, L. ("Hardun" of the Arabs), the large repulsive-looking lizard so common about cactus hedges in Palestine, may be among the sheltered retreats serving the insects as nurseries. At Deir el Belah, 13.viii.1917, at 10.30 a.m., the writer found *Ph. papatasii* abundant in an E.P. tent, situated in a garden close to a well and occupied as sleeping quarters by engineers working the pump at the latter. The insects were in numbers in the upper corners of the tent, sheltering behind the valances and at the back of framed photographs hung across the corners; there were also several inside helmets and coats hanging on the tent-pole. Both sexes were present, ♀♀, the majority of which were gorged with blood, perhaps slightly predominating; over 20 specimens were caught in tubes with little difficulty. At

\* Newstead, Bull. Ent. Res., ii, p. 73 (1911).

Jericho, in May-June 1918, *Ph. papatasii* was fairly common, and in the compound of the Pilgrim's Hospice at 4.45 a.m. on 7.vi.1918, the author was bitten on the back of the hand by a ♀ of this species, in broad daylight. On 2.x.1918, when occupying a tent on a spur of Mt. Carmel, above Haifa, the writer observed a ♂ *Ph. papatasii* inside his mosquito net.

**Phlebotomus minutus**, Rond., var. **africanus**, Newst.

The following are the data with regard to the few specimens of this insect brought back by the author:—1 ♂, near Jerisheh, 5 miles N.-E. of Jaffa, 7.v.1918, in author's tent, 8.0 a.m. ; 1 ♀, same locality and place, 15.v.1918, 7.15 p.m. ; 2 ♂♂, 2 ♀♀, near Yahudiyeh, about 8 miles E. of Jaffa, 24.viii.1918, in E.P. tent in olive grove ; 1 ♂, 6 ♀♀, and 3 ♂♂, 7 ♀♀, near Jerisheh, 26.viii. and 3.ix.1918, behind hanging valance of E.P. tent, in open country.

In the Jaffa district, at any rate during the period July-September 1918, *Ph. minutus* var. *africanus* was generally to be found sheltering in numbers behind the hanging flaps or valances in E.P. tents, while, if the settlement of Wilhelma may be taken as a criterion, it was also common in villages. On 30.vii.1918, the writer was informed by Captain (afterwards Major) W. F. Corfield, D.A.D.M.S., 54th Division, that the fly was abundant in all the houses in Wilhelma, and that in the room used as the informant's mess, 40 or 50 specimens were sometimes seen, or were caught on the lamp, in one evening. On making a search in the office of the A.D.M.S., 54th Division, in Wilhelma, the writer found two examples of what appeared to be *Ph. minutus* var. *africanus*, while in the cellar-like basement of the same house several more specimens of this *Phlebotomus*, including a female gorged with blood, were seen and caught. Since every house in Wilhelma is provided with a basement, the walls of which, being built of rough stone, are full of cracks and crannies forming ideal breeding and sheltering places, the local abundance of these "sand-flies" was scarcely surprising, while, at any rate under active service conditions, effective prophylactic measures were of course impossible.

When collecting specimens of *Ph. minutus* var. *africanus* in their favourite retreats in E.P. tents, it was noticed that on first being uncovered they are often, or usually, so completely motionless that they appear to be dead. On being disturbed, however, they become very active, either jumping from side to side after the manner of *Ph. papatasii*, or just as frequently taking wing at once. Placed in tubes loosely plugged with cotton wool, these little flies frequently burrow into the wool like minute mice, and then remain perfectly motionless. In the Jerisheh-Wilhelma region, in the summer of 1918, occasional specimens of *Ph. papatasii* were seen or caught in company with *Ph. minutus* var. *africanus*, though the latter appeared to be far more numerous. Like *Ph. papatasii*, *Ph. minutus* var. *africanus* sometimes shelters among clothing hanging on tent-poles ; thus, near Jerisheh on 7.ix.1918, the author took 1 ♂ and 3 ♀♀ of this variety among the folds of a Burberry suspended from the pole in his tent. None of these females had blood in them, and no specimens of *Ph. minutus* var. *africanus* were ever observed to bite ; in fact the finding in the basement of a house at Wilhelma, as mentioned above, of a single female gorged with blood was the only evidence obtained that the present variety is actually a blood-sucking fly. It only remains to add that whenever a series of specimens was collected, females were found to be much more numerous than males, and that a single male taken by the writer, 26.ix.1918, in his tent at Tul Keram, appeared to belong to the variety under discussion.

Writing from observations made during a five weeks' visit to southern Galilee and Syria in October and November 1912, Dr. N. Annandale says\* :—" By far the

\* Journ. Asiatic Soc. Bengal, ix, pp. 44-45 (1913).

most troublesome blood-sucking flies at Tiberias and Nazareth in October are the so-called sand-flies of the genus *Phlebotomus* (fam. Psychodidae). They occur in large numbers in every house, concealing themselves during the day in ceilings or dark corners to which they retire shortly after sunrise, and commencing their onslaught, which is continued until they retire, at sunset. Although I was unable to find the larvae, I obtained indirect evidence that they breed in half-dried algae just above the water level on the sides of open cisterns. Miss S. L. M. Summers, of the London School of Tropical Medicine, who has been kind enough to examine the adult specimens I collected, finds only two species (*Ph. papatasii* [sic], Scop., and *Ph. minutus*, Rond.), among them, thus confirming the preliminary diagnosis made in the field. Col. Alcock tells me that he found the same two species, and them only, in a large collection from Aleppo. *Phlebotomus* apparently occurs at Tiberias practically throughout the year, but at Damascus, in which it is troublesome in summer, it had entirely disappeared before the end of October. I did not obtain *Ph. minutus* at Nazareth, and at Tiberias it was much less common than *Ph. papatasii*."

Genus et sp. incert.

At Bir Esani, 24.x.1917, in the Wadi Immalaga near its mouth, on a ladleful of water just taken from among bulrushes, the author found a small Psychodid with a distinct proboscis and slightly spotted wings. Most unfortunately the specimen, which was quite unlike anything seen before or since, was blown away before it could be secured.

Family MUSCIDAE.

Genus **Philaematomyia**, Austen.

**Philaematomyia crassirostris**, Stein.

*Musca crassirostris*, Stein, Mitt. Zool. Mus. Berlin, ii, p. 99 (1903)

*Philaematomyia insignis*, Austen, Ann. & Mag. Nat. Hist. (8) iii, p. 298, figs. i-iii (1909).

Eleven ♂♂; 11 ♀♀, Latron, close to Jaffa-Jerusalem road, 5.ix.1918; 1 ♀, Tul Keram, 26.ix.1918 (Lt.-Col. (temp. Col.) E. P. Sewell, C.M.G., D.S.O., R.A.M.C.).

— Although from the moment of entering Palestine the writer kept a sharp lookout for this widely-distributed species, it was not met with at all during 1917, and even in 1918 it was not observed until 5th September, when the author took it in abundance on his own person, at Latron. Had cattle been examined, the fly would very possibly have been encountered earlier.\* Patton and Cragg,† writing of *Philaematomyia insignis*, Austen (= *Ph. (Musca) crassirostris*, Stein), as observed by them in Madras, state that flies of this species "feed almost exclusively upon cattle and . . . . only occasionally bite human beings." The present writer's experience tends to support this statement. At Latron on the date mentioned he took both sexes of *Philaematomyia crassirostris* in numbers on his puttees (24 specimens—11 ♂♂, 13 ♀♀—were caught without difficulty in a killing tube), all the insects being actively engaged in probing the material with their proboscises, evidently in search of nutriment; while, although the writer's arms were bare and perspiring, only a few specimens settled upon them, and only one of these latter flies (a ♀)

\* In Galilee, in October 1912, according to Dr. N. Annandale, the present species was "by far the commonest blood-sucking fly on horses and cattle" — cf. E. Brunetti, "Some Noxious Diptera from Galilee" (Journ. Proc. Asiatic Soc. Bengal, ix, p. 43, 1913).

† Annals of Tropical Medicine and Parasitology, v, p. 518 (1912).

attempted to bite. It was felt at the time that so unmistakable a predilection for settling upon and feeding from a hairy surface could scarcely be without significance. The ♀ taken in the act of biting the author's arm caused a sharp, pricking sensation, which lasted for several minutes, although there was no visible blood at the bitten spot. The ♀ caught at Tul Keram by Colonel Sewell bit its captor on his bare leg at 7.30 a.m., while he was dressing in his tent; though disturbed before it had time to draw blood, the fly left a mark upon the skin.

The greyness of the ♀♀ of this species in life is very noticeable; male specimens do not appear nearly so grey. Another remarkable characteristic of this fly is the softness of its body; when pinning the specimens taken at Latron, which did not appear to be newly-emerged, the author found it difficult to impale them on No. 20 pins, without crushing in the dorsum of the thorax, and the contrast in this respect between *Ph. crassirostris* and *Musca domestica* or *M. autumnalis* was most striking.

Genus **Stomoxys**, Geoff.

**Stomoxys calcitrans**, Linn.

One ♂, 2 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 7.20.iv.1917; 1 ♀, Jaffa, 26.ii.1918, in house; 1 ♀, Wadi Hanein, near Richon le Sion, 9.iv.1918; 1 ♂, 1 ♀, Deiran, 11.iv.1918, *in cotitū*.

Generally distributed. Brunetti (*loc. cit.*) states that in October 1912 this species was met with in houses at Nazareth and Tiberias by Dr. N. Annandale, who writes (*ibid.*) that it was "also seen commonly on cattle."

Genus **Lyperosia**, Rond.

**Lyperosia irritans**, Linn.

Fairly common in Wadi Ghuzze, near El Shellal, 11.xi.1917, when a number of specimens settled on author's sleeve, but did not attempt to bite; 1 ♂, 3 ♀♀, Ain es-Sultan, near Jericho, 22.iv.1918, on horses.

[**Lyperosia minuta**, Bezzi.—Brunetti (*Journ. Proc. Asiatic Soc. Bengal*, ix, p. 43, 1913) records a single ♀ of this species as having been taken at Tiberias, in October 1912, by Dr. N. Annandale, who writes (*loc. cit.*):—"The specimen was caught biting my hand at night. What I take to be this species is very troublesome, especially in the early morning and at sunset, on the shores of the Lake of Tiberias, easily piercing ordinary flannel with its proboscis. The wound is not very painful and does not as a rule become inflamed."]

Family HIPPOBOSCIDAE.

Genus **Hippobosca**, Linn.

**Hippobosca equina**, Linn.

One ♀, near Jericho, 6.iii.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*); 1 ♀, Deir el-Belah, 8 miles S.-W. of Gaza, v.1917; 1 ♀, near Jerisheh, 5 miles N.-E. of Jaffa, between 1.v. and 8.v.1918; 1 ♂, 1 ♀, Mulebbis, 21.v.1918, on cow (*Captain C. Searle, M.C., R.A.M.C.*); 1 ♂, Jericho Plain, 26.v.1918, on horse; 3 ♀♀, Mount of Olives, 26.v.1918, on horse (*Captain (acting Lt.-Col.) Dale*); 1 ♂, 1 ♀, Mount of Olives, 20.vi.1918, inside Kaiserin Auguste-Viktoria Stiftung; 1 ♂, Tul Keram, 27.ix.1918.

Brunetti (*loc. cit.*, p. 44) mentions that in October 1912 specimens of this species were taken by Dr. N. Annandale at Tiberias, Nazareth, and Kefr Kenna, "sucking blood of horses." The collector states (*loc. cit.*) that in Galilee *H. equina* is "very common on horses and cattle."

**Hippobosca capensis**, v. Olf.

One ♂, 1 ♀, Deir el-Belah, 8 miles S.-W. of Gaza, v.1917; 1 ♂ near Kefr Insha, about 20 miles E. of Jaffa, 21.v.1918, settled in ear of author while he was travelling in motor car; 1 ♂, Mount of Olives, 6.vii.1918, inside Kaiserin Auguste-Viktoria Stiftung, on author's neck; one specimen (sex uncertain, abdomen missing), near Abud, 19 miles E. of Jaffa, 25.viii.1918, on author's arm.

**Hippobosca camelina**, Leach.

One ♂, near Jericho, 6.iii.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*); 1 ♀, Tel es-Sultan, near Jericho, 21.iii.1918, caught in horse lines, with many specimens of *Hippobosca equina*, Linn. (*Captain W. W. Averill, Auckland Mtd. Rifles*); 1 ♂, 4 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 2.ix.1917, on camels.

It may be mentioned that a somewhat misshapen pupa (puparium), deposited prematurely by one of the specimens last referred to, measures 7 mm. in length, while the dimensions of a fully mature, empty puparium of *H. camelina*, obtained at Biskra, Algeria, 3.iii.1894 (*Rev. A. E. Eaton*) are—length, 6 mm., greatest breadth, 5.4 mm.

Owing to the very large number of camels (some 30,000), chiefly from Egypt, serving with the Egyptian Expeditionary Force in 1917-18, this species could have been taken practically anywhere within the British lines in Palestine, at any rate wherever there was a detachment of the Imperial Camel Corps or section of the Camel Transport Corps.

Genus **Lynchia**, Weyenb.**Lynchia maura**, Big.

Three ♂♂, 3 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 23.viii.1917, on carrier-pigeons belonging to Army Signal Service, R.E.

In the warmer parts of the earth, including southern Europe, this well-known parasite of the domestic pigeon and disseminator of the haematozoon, *Haemoproteus columbae*, Celli & Sanf., is nowadays to be found on its host practically wherever the latter occurs. The *Lynchia maura* series already in the British Museum (Natural History) includes specimens from the Canary Islands (Orotava, Teneriffe); N. Nigeria (Hadeija); Nyasaland Protectorate (Kanyenda, Dwangwa R., W. Nyasa); Union of South Africa (Cape Town, and Mowbray, Cape Province; Pretoria and Onderstepoort, Transvaal); Mauritius; Mesopotamia (Qurnah, R. Tigris); India (Deesa, Ambala, Bangalore); Selangor (Kuala Lumpur); Jamaica (Spanish Town); and Brazil (Pará). Knab (Insec. Inscit. Mens., iv, 1916, p. 3), who gives records ranging from Iowa to Southern Brazil (S. Paulo), states that the species "is widely distributed in America," and that recently it "has made its appearance in the Hawaiian Islands."

Apart from the dissemination of haematozoa, pathogenic or otherwise, by *Lynchia maura*, these flies, several of which may occur on the same bird, are prejudicial to carrier-pigeons by disturbing their rest. It was found in Palestine that an infested pigeon on returning from a flight, instead of at once seeking its resting place, as these birds usually do, would alight on the floor of the loft and proceed to stamp and peck itself.

Genus **Lipoptena**, Nitzsch.**Lipoptena caprina**, sp. n.

♂♀.—Length, ♂ (7 specimens), 3.2 to 3.8 mm. (from anterior margin of clypeus to posterior margin of scutellum, 2 to 2.2 mm.), ♀ (3 specimens), 3.8 to 5 mm. (from anterior margin of clypeus to posterior margin of scutellum, 2.4 mm.); width of head, ♂, 1 to just over 1 mm., ♀, 1.25 mm.

*Dorsum of thorax* (in dried specimens) shining mummy-brown; chitin plates on dorsum of abdomen small (first three plates in ♀ minute); entire dorsum of abdomen of ♂ from posterior margin of basal segment backwards inclusive, except greater part of the four plates of chitin and area immediately in front of last plate, thickly clothed with relatively long, recumbent, cinnamon-rufous hair; corresponding area of dorsum of abdomen of ♀ clothed for most part with very short hair.

*Head*: dorsal surface, including antennae, ochraceous-tawny, vertical triangle (ocelligerous plate) dark brown or dark mummy-brown, nearly semi-circular and extending much further forward than in *L. cervi*, *L.*, frontal stripe cinnamon-brown, sepia-coloured or light mummy-brown, about half as broad again as long; each inner orbit at its widest equal to or slightly exceeding extreme breadth of corresponding eye; clypeus generally with a more or less distinct, isolated, pit-like depression in middle line, midway between pit at posterior end of median longitudinal groove and its hind margin, a dark brown horseshoe-shaped mark (more or less complete or widely interrupted in middle line), usually fairly well defined, and with forwardly directed concavity, encircling pit at end of median longitudinal groove, each arm of the horseshoe running along inner edge of corresponding antennary pit, but not reaching front margin of clypeus, a second, narrower, dark brown, curved mark, interrupted in middle line by posterior pit-like depression, behind horseshoe and midway between it and posterior margin of clypeus, arms of posterior curved mark not extending so far forward as those of horseshoe, area adjacent to pit at posterior end of median longitudinal groove brownish; palpi dark brown, short; hair on ventral surface of anterior border of head brownish at base, glistening ochraceous-tawny towards distal extremity. *Cephalic chaetotaxy*: one bristle close to inner upper angle of each orbit, on a level with posterior ocelli; two bristles side by side on each inner orbit, in a row extending obliquely forwards and inwards on a level with upper margin of eye; one bristle (occasionally two bristles) on inner margin of each orbit close to upper boundary of clypeus. *Thorax*: dorsum clothed with hair and bristles of moderate length, dark brown at base, glistening cinnamon-rufous towards their distal extremities; middle line of mesonotum bordered on each side with a curved row of bristles, commencing anteriorly a little in advance of hind margin of humeral callus; humeral calli each with six or seven bristles, postalar calli each with three bristles; lateral area of mesonotum on each side clothed fairly thickly with bristles, of which those forming a transverse row on upper surface of protuberance in front of base of each wing-stump are stouter and recurved; scutellum sometimes showing a pit-like depression (perhaps due to *post mortem* shrinkage) near each lateral angle, sometimes also with a similar depression in middle line; hind margin of scutellum with six bristles. Each half of mesosternum roughly quadrate in outline when seen from below, considerably larger than corresponding half of metasternum, and closely beset with very short dark brown bristles, those on hind margin, apart from usual long, hair-like bristle in front of socket of middle leg, larger and stouter than elsewhere; short bristles on metasternum smaller and fewer than those on mesosternum, though in this case also bristles on hind margin are stouter than remainder. *Abdomen*: dorsum of ♂ with basal segment of usual type, followed in middle line by four small, transversely elongate plates of shining dark brown chitin, widely separated by pinkish buff or cinnamon-buff integument; transverse diameter of last two plates about the same (0.6 mm.), but last plate considerably deeper (*i.e.*, longer when measured from front to rear) than penultimate, the two anterior plates very small, one-third or considerably less than half the size of the penultimate, basal segment, except hind margin, clothed with short, appressed, dark brown hair; venter cinnamon-buff, with a large horseshoe-shaped, dark neutral grey mark not extending to distal extremity, and entire surface thickly clothed with short hair, similar in colour and character to that on dorsum; dorsum of abdomen of ♀ with basal segment similar to that of ♂, followed in middle line by four plates of chitin widely separated by light ochraceous-buff integument, the terminal plate,

consisting of dark brown chitin, situate at bottom of notch or depression in hind margin of abdomen, and about equal in size to corresponding plate in ♂, remaining plates very small, light mummy-brown in colour and transversely elliptical or elliptical oval in shape, the penultimate plate and the plate immediately following the basal segment between one-third and one-fourth of the terminal plate in size, the ante-penultimate plate considerably smaller than either of the two plates between which it is situate; dorsum in ♀ sparsely clothed with appressed, dark brown, chestnut-brown or cinnamon-rufous hair, very short except on hind margin of basal segment and on lateral margins of posterior half of abdomen, and, with exceptions stated, much shorter than corresponding hair in ♂, each of the four median chitinous plates with a more or less complete row of short hairs, varying in number, on or close to its hind margin; venter cinnamon-buff, fairly densely clothed with minute, appressed, dark brown, chestnut-brown, or cinnamon-rufous hair. Legs, except tarsi, buff-yellow or ochraceous-buff, front and middle femora brownish above towards distal extremities, anterior surfaces of front and middle tibiae also more or less brownish; tarsi cinnamon-brown or chestnut-brown; bristles and hairs on legs dark brown to cinnamon-rufous, stouter bristles dark brown at base, then paler.

Jerusalem and Ain Arik (10 miles N.N.-W. of Jerusalem): type of ♂, and 5 ♂ and 2 ♀ para-types, taken at Jerusalem, 29.vi.1918, on goats and kids; type of ♀, and 1 ♂ para-type, caught at Ain Arik, 15.vii.1918, on a kid. In all cases the insects were on the inside of the thighs; at Jerusalem, on 29.vi.1918 several specimens were found on one small kid. It may be noted that, in addition to harbouring the parasite just described, the goats examined, which appeared to be perfectly healthy, were also infested with ticks, specimens of which, apparently belonging to two or three species, were numerous on the inside of the animals' ears.

Among the microscopic preparations forming part of the National Collection of Diptera is a ♀ *Lipoptena*, which is evidently conspecific with the specimens enumerated above, and was taken on man at Snevce, Macedonia, in May 1918 (Col. C. M. Wenyon, C.M.G., C.B.E., late A.M.S.).

In general appearance *Lipoptena caprina* presents a close resemblance to *L. ibicis*, Theob. (Second Report Wellcome Research Labs., Khartoum, 1906, p. 88, figs. 45-47), which was described from specimens found on an ibex at Port Sudan, Anglo-Egyptian Sudan. The new species agrees with *L. ibicis* with respect to size, etc., of the abdominal plates of chitin and as regards the hairiness of the body, but is distinguishable by the row of bristles running obliquely across each inner orbit consisting of only two instead of three or four, or sometimes even five bristles, and by the antero-posterior diameter of the vertical triangle (ocelligerous plate) being if anything slightly longer.

Owing to similarity of provenance, it might be reasonable to assume the identity of *Lipoptena ibicis*, Theob., with *L. chalcomelaena*, Speiser (Zeitschr. f. syst. Hym. u. Dipt., iv, p. 178, 1906), the typical series of which was obtained at Tor (Peninsula of Sinai) on "*Capra caucasica*" (*Capra aegagrus*, Gmel.?). While, however, the number of bristles in the row running obliquely across the inner orbits as given by Speiser for *L. chalcomelaena* agrees with what is found in *L. ibicis*, Speiser in describing the abdomen of the male of his species gives no indication of special hairiness; on the other hand he describes the vertical triangle on the head as "broad and short," whereas in *L. ibicis*, Theob., the antero-posterior diameter of the corresponding plate is considerably longer than in *L. cervi*, Linn. On the other hand, in a subsequent paper (*op. cit.*, v, p. 354, 1905), Speiser, when giving additional localities for his species, mentions that the majority of the specimens afterwards examined by him were collected in Egypt (two on the shores of the Red Sea), and that all of these bore a label with the MS. name of "*L. hirta*, Löw." This would suggest that if Speiser has correctly identified these latter specimens as belonging to his own species, *Lipoptena ibicis*, Theob., may still be a synonym of *L. chalcomelaena*, Speiser.



#### EXPLANATION OF PLATE IV.

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Fig. 1.—Wing of *Culicoides tentorius*, Austen, ♀.  $\times 75$ .  
Fig. 2.—Wing of *Culicoides odibilis*, Austen, ♂.  $\times 75$ .  
Fig. 3.—Wing of *Culicoides newsteadi*, Austen, ♀.  $\times 75$ .

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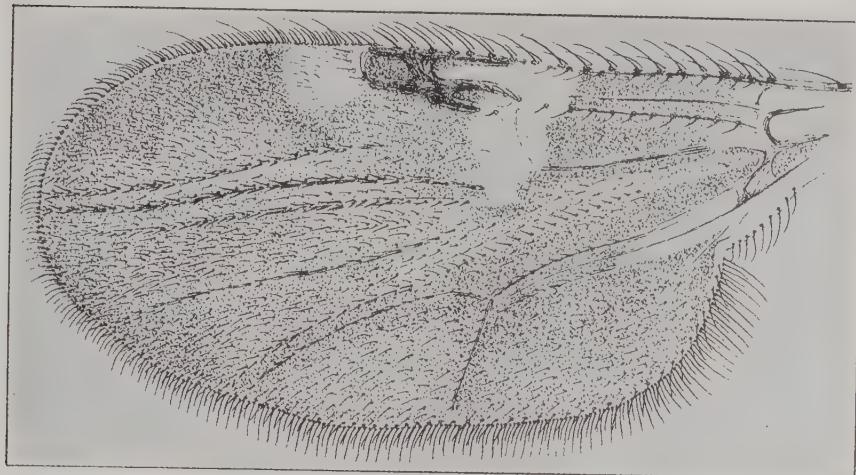


Fig. 1. *Culicoides tentorius*, sp. n., ♀ ( $\times 75$ ).

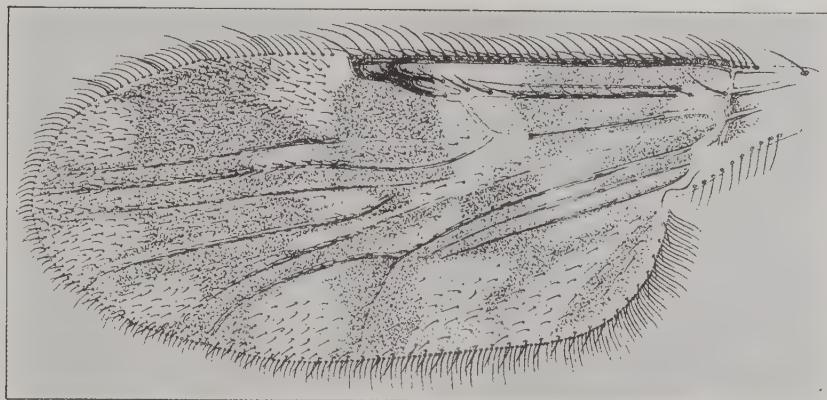
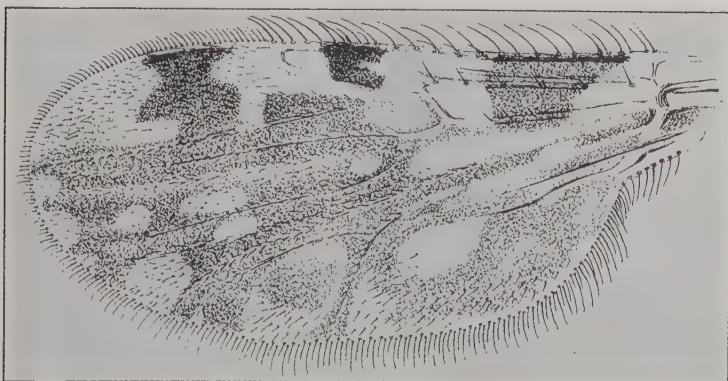


Fig. 2. *Culicoides odibilis*, sp. n., ♂ ( $\times 75$ ).



E. E. Austen ad nat. del.

Fig. 3 *Culicoides newsteadi*, sp. n., ♀ ( $\times 75$ ).



## COCCIDAE FROM THE SEYCHELLES.

By E. E. GREEN and F. LAING.

**Pseudaonidia iota, sp. n.**

Adult female pyriform, broadest across the meso- and metathorax; cephalothoracic area rounded in front, slightly contracted behind, where there is a well-defined transverse groove; abdomen tapering to the posterior extremity; frons and margins of thorax and abdomen with a few spiniform setae. Antennae rudimentary, each bearing a single long straight seta. Anterior spiracles with a small group of para-stigmatic pores (fig. 1, A). Pygidium with a well defined, strongly chitinised, pyriform, reticulated area, the lacunae oval or round, and disposed regularly; the part posterior to the anus, very heavily chitinised, obscuring the lacunae. Circumgenital glands present, consisting of a continuous arch representing the united median and

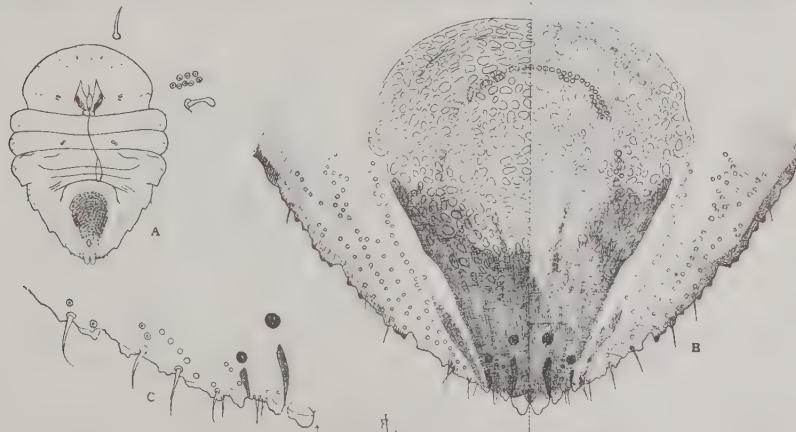


Fig. 1. *Pseudaonidia iota*, sp. n.: A, adult,  $\times 30$ ; B, pygidium,  $\times 150$ ; C, margin of pygidium,  $\times 250$ .

anterior lateral groups, with the posterior laterals separated by a short space; the anterior laterals show signs of being in two rows. Dorsal pores numerous, comparatively small, circular, arranged in longitudinal series on each side of the pygidium, and extending on to the margins of the abdomen (fig. 1, B). Pygidial margin with three pairs of lobes and numerous angular projections laterad, each lobe notched on the outer side; two pairs of conspicuous claviform paraphyses, each with a large separate circular knob like the dot of an *i* (fig. 1, C). Length, 1 mm.; greatest breadth about 0.75 mm.

Described from a single example.

On upper surface of leaf of *Eugenia caryophyllata*, Seychelles (P. R. Dupont).

The paraphyses of this species resemble those to be found in *P. lacinia*, Brain (Bull. Ent. Res., ix, 3, p. 207, March 1919), but the two species may be readily separated by the absence of circumgenital glands in the latter.

**Pseudaonidia aldabraca, sp. n.**

Puparium of female more or less circular, brownish, partly overlaid with greyish-white secretion. Diameter approximately 2 mm.; exuviae subcentral.

Adult female broadly ovate, broadly rounded in front, bluntly pointed behind, deeply incised on each side of the body immediately behind the cephalo-thoracic area; broadest across the metathoracic area, *i.e.*, shortly behind the lateral incision. The whole insect rigid, rather densely chitinous. Rudimentary antennae obsolete or inconspicuous. Anterior spiracles with a small group of parastigmatic pores; posterior spiracles rather inconspicuous, with no pores. Segmental divisions of abdomen marked by strong transverse folds which do not extend to the lateral margins. A few longish spiniform setae at intervals along the margins of abdomen (fig. 2, A). Pygidium not sharply defined; its centre occupied by a large reticulated area, the lacunae very irregular in size, form and disposition; no circumgenital glands; dorsal pores small, but numerous (fig. 2, B). Margin of pygidium with three pairs of lobes; the median pair larger and more prominent, bluntly conical; second and third pairs rather shallow, the apex of each nearer the inner side, more or less conspicuously notched on the free edge. There is a suggestion of a fourth lobe in the form of a sub-angular marginal prominence. Squames minute and inconspicuous; a pair between the median lobes; a second pair in the intervals between the median and second lobes; and one (possibly two) between the second and third lobes. There



Fig. 2. *Pseudaonidia aldabra*, sp. n.: A, adult,  $\times 30$ ; B, pygidium,  $\times 150$ ; C, margin of pygidium,  $\times 225$ .

are three conspicuous crescentic incrasations, within the margin on each side, associated with short but rather stout paraphyses which extend inwards from the interval between the median and second lobes and from the inner side of the third and of the rudimentary fourth lobes. There is also a pair of short and more or less confluent paraphyses between the median lobes (fig. 2, C). Length, 1.25 mm.; greatest breadth, 1 mm.

Described from a single example.

On bark of "Bois d'Amande," Aldabra Island, Seychelles (*P. R. Dupont*).

This species is near to *P. tesseratus*, d'Emm., but differs principally in its smaller size, and in the absence of the strongly cristate lateral margins of the pygidium.

#### ***Aonidia obtusa*, sp. n.**

Female puparium consisting almost entirely of the enlarged nymphal pellicle, transversely oval, flat, or very slightly convex, a narrow marginal area ornamented with sutures running irregularly from without inwards and intertwining; colour varying from pale to dark brown, often thinly coated with white powdery secretion over a wide marginal area, leaving only the centre bare (fig. 3, A). Pygidium recessed,

the extremity scarcely projecting, deeply incised on each side near the base; margin with a pair of narrow median lobes between which are two narrow squames, laterad are two squames, a lobe, three squames, and then three lobes; squames slightly fimbriate. The basal areas (beyond the incisions) each with three prominent angular projections. There are two pairs of broad (but obscure) semilunar pores, occupying the intervals between the median, second and third lobes, and communicating with conspicuous tubular ducts (fig. 3, B). Breadth, 1-1.16 mm.; length, 0.75 mm.

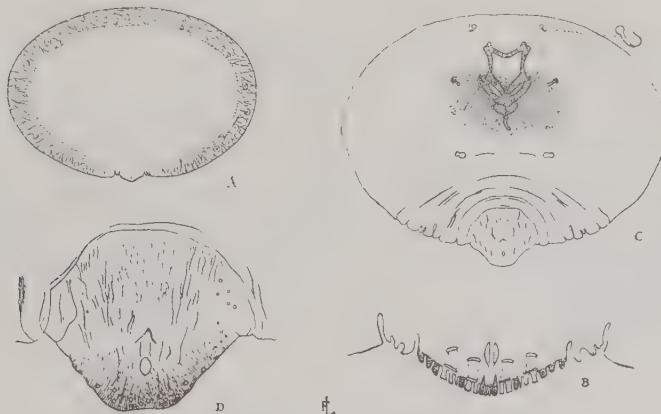


Fig. 3. *Aonidia obtusa*, sp. n: A, nymphal pellicle,  $\times 33$ ; B, pygidial margin of same,  $\times 225$ ; C, adult,  $\times 50$ ; D, pygidium of adult,  $\times 150$ .

Adult female broadly ovate, 0.8 to 0.95 mm. broad, by 0.75 mm. long; abdominal segments compressed but visible. Antennae rudimentary, composed of a short curved spine situated on a tubercle. Mouth-parts strongly developed; area surrounding mouth and anterior spiracles more densely chitinised than the rest of the body (fig. 3, C). Pygidium obtuse, without a vestige of lobes or other processes; and with several conspicuous sub-marginal pores (fig. 3, D).

On *Verschaffeltia splendida*, Seychelles (P. R. Dupont).

Four names may be added to the list of COCCIDAE already recorded from the Seychelles.

1. **Ceroplastes rubens**, Mask.

On fern (*Acrostichum* sp.). Widely distributed in the Australasian region.

2. **Chionaspis subcorticalis**, Green.

On tomatoes, Astove Island, and on *Sida* sp., Assumption Island. Hitherto recorded from Ceylon only.

3. **Pinnaspis buxi**, Bouché.

On *Pandanus seychellarum*, Felicité Island; also on *Areca catechu*. An almost cosmopolitan species.

4. *Diaspis (Aulacaspis) flacourtiæ*, Rutherford.

On *Flacourtia*. Previously known from Ceylon only.

As Rutherford published his description (Bull. Ent. Res., v. 3, Dec. 1914, p. 259) without any figures, we take this opportunity of supplying the omission (see fig. 4, A, B).

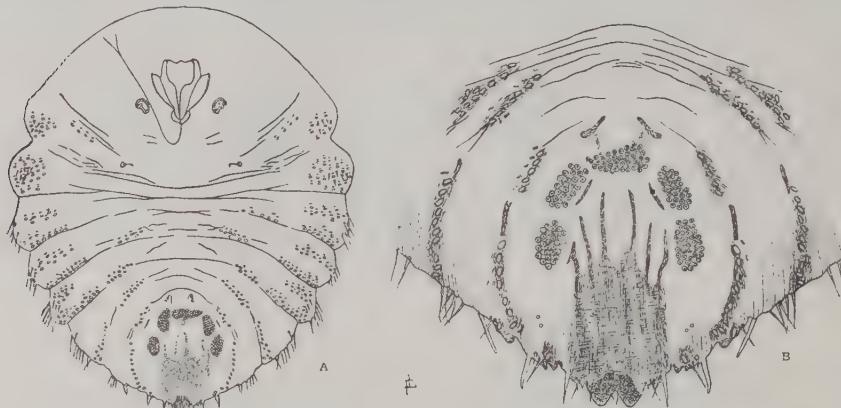


Fig. 4. *Diaspis flacourtiæ*, Rutherford. : A, adult,  $\times 50$  ; B, pygidium,  $\times 150$ .

The species differs from *pentagona*—which it closely resembles—in the relatively larger and more prominent median lobes, and in the obsolescent or very small lateral lobes of the pygidium. The dentiform first lateral lobe, which is a prominent feature in typical *pentagona*, is altogether lacking in *flacourtiæ*. The pores on the lateral margins of the body are far more numerous and conspicuous in *flacourtiæ*.

Rutherford makes no mention of the pathological effect upon the host-plant that is noticeable in Ceylon, where the insect causes a stimulation of growth in the sub-lying woody tissue, causing irregular and conspicuous swellings on the infested areas of the branches of *Flacourtia*. This effect is noticeable only upon the older and mature branches. When the smaller and younger branches are attacked, there is no such tendency to an abnormal growth.

## ON THREE NEW SPECIES OF INDIAN BRACONIDAE.

By G. T. LYLE, F.E.S.

The following descriptions are based on material submitted for determination by Mr. T. Bainbrigge Fletcher, the Imperial Entomologist, Pusa, Bihar.

## Family BRACONIDAE.

Genus ***Micropilitis***, Först. (1862).***Micropilitis similis*, sp. n.**

Black; palpi pale; legs testaceous, hind coxae at base and hind femora darker, apical joint of all tarsi fuscous; sides of abdominal segments 1 and 2 testaceous. Wings hyaline, nervures fuscous, stigma unicolorous, testaceous or fuscous-testaceous. Antennae of male as long as body, of female one-third shorter, fuscous-testaceous, scape rather darker and flagellum darker towards apex. Head and mesothorax granulate; scutellum smoother, dull; metathorax rugose, with indications of a longitudinal medial carina. Abdomen smooth and shining, only first segment feebly striolate; shield of first segment twice as long as medial breadth, slightly narrowed towards base and rounded at apex; second segment without noticeable impressed lines. Spurs of hind tibiae barely one-third as long as metatarsus. Terebra very short. Length, 2½-3 mm., expanse, 5-6 mm.

Cocoons pale tan colour, similar to those of *M. spectabilis*, Hal.

Type ♀, in the British Museum; cotypes in the Pusa Collection.

A parasite of *Agrotis ypsilon*, L., from the following localities:—

BIHAR & ORISSA: Pusa, 1 ♂, 4 ♀, 16.iii.1914 (type material); Sabour, 2 ♀ (H. L. Dutt). BENGAL: Mokamah, 1 ♂, xii.1911 (D. N. Pal), and 2 ♂, 18.xii.1911 (C. S. Misra).

Very near *M. spectabilis*, Hal., indeed at first I considered it to be a form of that species, but the invariably unicolorous stigma and feebly longitudinally striolate first segment of the abdomen would appear to warrant its separation. *M. spectabilis*, a common European species, has the stigma determinately pale at the inner angle, the first abdominal segment minutely punctuate, and the hind and middle tarsi fuscous.

***Micropilitis eusirus*, sp. n.**

Black; palpi pale; legs rufo-testaceous (fore and middle coxae and middle femora except at apex fuscous, hind legs entirely black or blackish excepting trochanters and tarsi towards apex, which are often rufo-fuscous). Sides of first and second abdominal segments lighter in colour. Wings infumated, with the usual dark blotch under the stigma; nervures fuscous; stigma unicolorous, dark fuscous. Antennae stout, rufo-fuscous; scape rufous at base; each joint of flagellum centrally marked with an impressed band which gives the antennae the appearance of having twice as many joints as is actually the case (this character is noticeable in a lesser degree in some of the European species). Eyes pilose. Head and mesothorax densely and minutely punctuate; sutures of the mesothorax deeply and clearly impressed; scutellum rugulose. Metathorax coarsely rugose, with a medial transverse centrally angulated carina, after which the metathorax falls suddenly away (fig. 1, a). Abdomen smooth and shining; shield of first segment elongate, three times as long as medial breadth, with parallel sides, slightly widened at base and

truncate at apex (fig. 1, *a*), apical tubercle not prominent. Spurs of hind tibiae pale, less than one-third as long as metatarsus. Terebra very short. Length,  $3\frac{1}{2}$ –4 mm., expanse, 7–8 mm.

Type ♀ in the British Museum; cotype in the Pusa Collection.

BIHAR & ORISSA: Pusa, 1 ♂, 2 ♀ and fragments of 2 others reared from *Achaea janata*, L., 20.ix.1912 (H. L. Dutt).

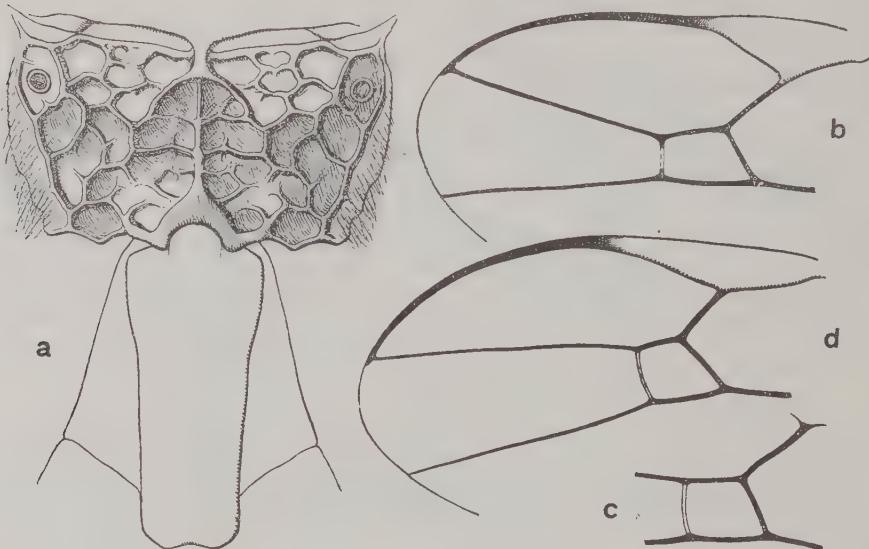


Fig. 1 (*a*). Propodeon and first abdominal tergite of *Microplitis eusirus*, sp. n., ♀; in the propodeon only the major reticulations are shown; the point of view is at right angles to the median carina, and the dorsal surface (unshaded) is seen considerably foreshortened; only the outline of the plate on the 1st tergite is indicated.

(*b*). *Rhogas (Heterogamus) percurrens*, sp. n., ♀; detail of wing.

(*c*). *Heterogamus dispar*, Curt., ♂; detail of wing.

(*d*). *Heterogamus dispar*, Curt., ♀; detail of wing.

#### Genus **Rhogas**, Nees (1818).

The following species is, formally at least, referable to *Heterogamus*, Wesm. (1838), but the difference between the first and second abscissae of the radius is so slight that the insect might with almost equal propriety be placed in *Rhogas*, Nees (fig. 1, *b*). The genotype of *Heterogamus*, Wesm. (*H. dispar*, Curt.) is a rare and extremely distinct species, and quite possibly *Heterogamus* may be a valid genus; but if so, it is not yet properly understood and its real differentiae have not been fully signalised. I have not had before me sufficient material of the genotype to satisfy myself on this point, and for the present treat *Heterogamus* as a subgenus. It can deserve no higher rank than this if its only criterion be the ratio between the first and second radial abscissae.

**Rhogas (Heterogamus) percurrens, sp. n.**

♀.—General colour of antennae,\* body and legs pale ferruginous. The ocellar triangle, but not the ocelli themselves, blackish. Mesonotum with a broad longitudinal faintly infuscated band inside each notaulus and two narrow short ones on the mid lobe anteriorly. Wings with costa, including basal three-fifths of the stigma, concolorous with the body, apical two-fifths of stigma infuscated. Nervures mainly darkened, but the second abscissa of the cubitus very pale. Abdomen a little darkened posteriorly from about the middle of the fourth tergite. Venter all pale; sheath of ovipositor blackish brown. Antenna with joints subequal, about one-third longer than broad. Thorax with transverse sulcus at base of scutellum crenulate with about eight large punctures or pits. Sides of scutellum with seven to eight short, stout, parallel ridges. Metanotum, apart from the usual divisions, smooth. Propodeon, in the type, with the median keel not completely percurrent, reaching back only to about two-thirds; the surface on each side of the keel irregularly rugulose; spiracle moderate, oval, a little over twice its length from the anterior edge.

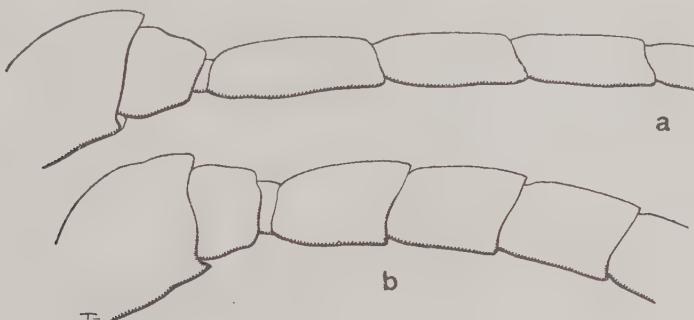


Fig. 2. Basal portion of antenna of (a) *Heterogamus dispar*, Curt.; (b) *Rhogas (Heterogamus) percurrens*, sp. n.

In the wings (fig. 1, b) the second cubital cell is a little, but quite perceptibly, narrowed distally, the second abscissa of the radius being slightly inclined to the third abscissa of the cubitus; first intercubital nervure and second abscissa of the radius subequal, the latter again much longer than the second intercubital. The radius and cubitus strongly divergent distally. The stigma distinctly broad.

Abdomen with the median keel percurrent to the posterior edge of the third tergite, sharply defined throughout its course, though broader on tergite one. Throughout its course the mid keel is flanked by numerous subparallel longitudinal ridges or rugae, these being continuous from tergite to tergite and extending even to the anterior or basal one-third of tergite 4. The first three tergites are rigid, and the sutures (especially the first) deep and distinct. The second suture (between two and three) might almost be described as crenulate, as the sulcus is cut into little pits by the percurrent rugae. Beyond the basal one-third of the fourth tergite the surface is smooth; only the smooth edge of the fifth tergite is visible.

Length just over 5 mm.; alar expanse, 9 mm.

Type a ♀ in the British Museum.

\* In the single antenna preserved, which is complete up to the 23rd joint (21st of the funicle) the colour is uniformly pale ferruginous without any suggestion of banding.

BIHAR & ORISSA: Pusa, a unique ♀ reared from *Achaea janata*, L., 7.x.1912 (C. R. Dutt).

*R. percurrens* sp. n., has a strong but probably superficial resemblance to *Heterogamus dispar*. So far as colour is concerned the resemblance is to the ♂ of that species. In colour, however, *dispar* is notoriously variable. It is possible that the darkening of the thorax and abdomen in *percurrens* owes something to the drying up and discoloration of the underlying musculature of these regions.

*H. dispar* is easily separated from the present insect (a) by the basal antennal joints, which are at least twice as long as broad (fig. 2); (b) in the wings (fig. 1, c, d), the radial cell is longer and more acute, the second cubital cell "higher" (♀, ♂), the second abscissa of the radius being just shorter (♀) or much shorter (♂) than the first intercubital. The same abscissa is again equal to (♀) or much shorter than (♂) the second intercubital. The radius and cubitus are less abruptly divergent distally and the stigma is narrower. In the abdomen the median keel is percurrent to the posterior margin of the second tergite only in the material available for examination.

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THE PTINID BEETLE, *TRIGONOGENIUS GLOBULUM*, SOLIER,  
BREEDING IN ARGOL.

By HUGH SCOTT, M.A., Sc.D., F.E.S.,

*Curator in Entomology, University of Cambridge.*

In March 1920 my attention was called by Dr. F. W. Dootson, University Lecturer in Chemistry, to the fact that a beetle was breeding in numbers in a jar of argol in the Chemical Laboratory of Cambridge University. The insect proved on examination to be the introduced Ptinid, *Trigonogenius globulum*, Solier,\* a form related to the household insect, *Niptus hololeucus*, to which it bears at first sight a slight resemblance.

Argol is the crust or deposit which separates out in barrels of new wine. It contains a high percentage of cream of tartar (potassium bitartrate), and most of the pure stock of that chemical is prepared from it. The argol in which the beetles were living was found to contain about 80 per cent. of potassium bitartrate. The argol was a purplish-red powder of close consistency, and it came to the Chemical Laboratory from London in a bag in 1913. It was placed in an earthenware jar, tightly corked with a wide cork bung. The powder did not quite fill the jar, but a very small air-space was left at the top.† I am assured that the jar was not opened from the time the powder was put in till early in 1920, when the argol was found to be full of adults and larvae of the *Trigonogenius*. The cork, which I have twice examined, has not been bored through or damaged by insects in any way, and it fits so closely that it is almost impossible that the beetles can have got into the jar down the side of the cork; nor have they been noticed anywhere else in the laboratory. Probably, therefore, some of the insects were in the argol when it came to the laboratory and have continued breeding in it all these years. No other kinds of insects were found in the argol. I am indebted to Dr. Dootson for most of the foregoing particulars and for samples of the infested chemical.

That the beetles were nourishing themselves, not exclusively on the 80 per cent. of potassium bitartrate, but at any rate partly on some of the ingredients forming the other 20 per cent. of the argol, seems to be indicated by the following experiment, carried out at Dr. Dootson's suggestion. Some of the insects were placed on the surface of about two inches depth of pure cream of tartar in a wide-mouthed corked bottle, with plenty of air-space between the surface of the chemical and the cork; 32 adults and 15 larvae were placed in this on 12th March 1920. Three and a half hours later almost all the larvae had burrowed down into the white powder, but the adults were still on the surface and showing signs of discomfort. Next day all the larvae but one were below the surface, and also about 23 of the adults; the remaining adults were still on the surface and one was dead. No further observation was made for nearly three weeks, when (on 1st April 1920) about 14 adults and one larva were seen to be on the surface, while the other 18 adults and 14 larvae had all burrowed some way down into the cream of tartar, and several burrows were visible against the glass sides of the bottle. The bottle was not examined again for nearly a year, when (on 15th March 1921) its contents were turned out, and all the insects were

\* Described by Solier in C. Gay's "Historia de Chile," iv, 1849, p. 464. I have retained Solier's original spelling of the specific name, though in some later works *globulum* is altered to *globulus*, which is probably more correct. Solier called the species *globulum*, but at the same time named a variety of it *globosus*. Why he gave the former name the neuter ending is difficult to say. He may have intended *globulum* to be a noun, but in several dictionaries of classical and late Latin which I have seen, the only form of the word is a late Latin noun, *globulus*.

† In some of the argol which was put into a glass-stoppered bottle, filling it up to the stopper and leaving no air-space, all the insects died.

found to be dead ; there were four adults on the surface and 34 adults below, and remains of about eight larvae were found. It will be noticed that the adults were six more in number than those placed in the bottle the year before, proving that some of the larvae had succeeded in reaching the adult state ; most of them when put in were fairly big. But the attempt to start a culture breeding in pure cream of tartar failed. It should be mentioned that no moisture was supplied, but neither was it, of course, in the original jar of argol, which was however far larger and contained a very much greater bulk of chemical than the bottle used in this experiment.

In the original jar of argol the insects were still present in large numbers in April 1921. Series of adults and larvae have been preserved, but I have found only one pupa, though samples of the argol have been looked through on several occasions. This single pupa was found at about the end of March 1921. Mr. Michael G. L. Perkins, who placed some of the argol in a vessel and kept the beetles present in it under observation, obtained about 30 pupae in July 1920. He has also started cultures of the insect in certain food-stuffs such as oatmeal and raisins, and, so far as his observations have gone, he considers that the generations succeed one another more rapidly in these food-stuffs than in the argol, in which substance the insects appear to be reproducing themselves only at the rate of about one generation a year. He hopes to publish the results of his investigations in the future.

The larva pupates in a cocoon formed of a feltwork of fine threads, secreted by itself. The cocoon is not lined, and the feltwork is easily pulled apart with needles into a loose tangle of threads. The feltwork appears whitish when the argol powder is shaken away from it. Under a high power ( $\frac{1}{2}$ -inch objective) the threads are quite colourless and transparent. Many full-fed larvae, pupae, and adults have been found in these cocoons by Mr. Perkins and myself. Mr. Perkins sifted the argol, to remove all foreign material from it, before he placed his observation culture of the insects in it, thereby proving that the threads are actually produced by the larvae. He thinks that other feltwork is produced in the burrows, besides that actually used in the construction of the cocoons.

*Trigonogenius globulum* was originally described from Chile, but is very widely distributed. In M. Pic's Catalogue of Ptinidae (1912, Col. Cat., part 41, p. 9), it is recorded from various parts of North and South America, Tasmania, and England. Most of the known species of the genus are, according to the Catalogue, known from Central or South America, and several of them are not known from elsewhere, so that region may be their native home. Fowler & Donisthorpe (Col. Brit. Isl., vi, 1913, p. 147) state that it has occurred in corn mills and granaries in various industrial centres in England. Champion (Ent. Mo. Mag., 1918, p. 40) records it as having been found under timber and among wood-shavings in London, in company with *Ptinus tectus* and *Niptus hololeucus* : and Potter (*op. cit.* 1919, p. 88) records it from old cotton mills near Manchester, where it was attracted to baits of sugar. It is not mentioned in Reitter's "Fauna Germanica : Die Kafer" nor in the addenda at the end of the last volume of that work (Vol. V, 1916), so it had evidently not occurred in Germany up till 1916 within the knowledge of the writers of that book. I have not searched the literature further. *Ptinus tectus* and *Niptus hololeucus*, the members of the same family mentioned above, are, like *Trigonogenius globulum*, found in various stored products. *Ptinus tectus* further resembles it in being almost cosmopolitan in range. It may be recalled that larvae and adults of *Niptus hololeucus* have recently been found in cocoa powder from a south German chocolate factory (Rev. Appl. Ent., A.ix, 1921, p. 66).

A REVISION OF THE GENUS *LOCUSTA*, L. (= *PACHYTYLUS*, FIEB.),  
WITH A NEW THEORY AS TO THE PERIODICITY AND MIGRATIONS  
OF LOCUSTS.

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## I. INTRODUCTORY.

The genus *Locusta*, L. (= *Pachytalus*, Fieb.) includes two of the most destructive swarming locusts of the Old World: the widely distributed *L. migratoria*, L. (with *L. danica*, L., and *L. migratorioides*, Rch. & Frm., as its forms; see below), and the South African *L. pardalina*, Walk. The literature on the economics, biology and especially on the means of control of these locusts is enormously extensive, but at the same time their systematic arrangement is in considerable confusion, and extremely contradictory opinions as to the mutual relationship of the different so-called species exist among specialists. As a direct consequence of this, the field research and control work of economic entomologists is apt to suffer through the difficulty in getting a particular species properly named,\* and thus it is often impossible to make a comparison of the records as to the biology and control of the same species in different countries.

Having had the opportunity of conducting, during the years 1911-14, extensive field research work and control work on *L. migratoria* in the northern Caucasus (Russia), and being a systematist, I could not fail to see at once that only very little progress could be made without a definite solution of the question of the interrelation between *L. migratoria* and *L. danica*, which latter has been accepted by many authors as a species distinct from *migratoria*, and as conspecific with it, by others. The same question arose before the Turkestan Entomological Station (in Tashkent) as soon as its staff began to work on *L. migratoria*.

Apart from my field work, which involved the study of immense series of living specimens in all stages, I endeavoured to gather all reliable information as to the distribution and local, individual and annual variability of *L. migratoria* and *danica* in different parts of their range, and owing to the support of entomologists and institutions throughout Russia and elsewhere, I managed to concentrate in my hands extremely rich materials from the following sources: Turkestan Entomological Station (V. J. Plotnikov); Astrakhan Entomological Station (N. L. Sakharov); Natural History Museum in Kherson (J. K. Pachosky); Zoological Museum of the Moscow University (Prof. J. Kozhevnikov); Caucasian Museum in Tiflis; Zoological Museum in Berlin. The following persons also contributed very valuable materials and information: Prof. I. Shtchelkanov, E. Jatzentkovsky, V. Artsimovich.

\* See, for instance, the interesting paper on the biology and control of the Malayan locust by H. C. Pratt (Bull. No. 27, Dept. Agric. Fed. Malay States, 1915), who states that "many attempts to identify this Malayan locust have been made and correspondence has been entered into with authorities throughout the world, but without success." He has been compelled to call the insect, simply, *Pachytulus* sp.

N. Ikonnikov, V. Boldyrev, L. Moritz, H. C. Pratt (Government Entomologist, Federated Malay States), and many others. Thanks to this generous help, I was able to come to certain conclusions on the question of *migratoria-danica* already in 1915, but the War and other circumstances prevented me from publishing a paper on it. When I arrived in London in 1920 and studied the exotic representatives of the genus *Locusta*, I felt the necessity of revising my previous work and extending its limits so as to include in it all known species and forms of the genus. This plan proved to be a very productive one, since a far more definite idea as to the inter-relations of different "species" has been thus reached. A study of the South African *L. pardalina*, Walk., has been also accomplished in the British Museum, but I could not do much with museum material only, and the most effective help in this respect has been rendered me by the Division of Entomology, Pretoria, and especially by Mr. J. C. Faure, who has sent to the Imperial Bureau of Entomology at my request extensive series of specimens, together with most valuable information.

With regard to the biological observations here recorded, it is only thanks to the help rendered me by my assistants, G. Vinokurov, Th. Gliniuk, the late G. Pirkovsky, and others, that I could collect the necessary facts. My most sincere thanks are due also to all the above-mentioned persons and the heads of institutions who have lent me material and supplied information.

## II. ON THE GENERIC NAME *LOCUSTA*, L.

The Linnean genus, *Gryllus Locusta*, includes 20 different species of locusts and grasshoppers, belonging to about as many modern genera. There is no wonder, therefore, that much controversy arose around the question as to the species to which the Linnean name *Locusta* must be restricted now. This question becomes still more complicated owing to the fact that Geoffroy (Hist. Ins. i, p. 396, 1762) applied the name *Locusta* quite erroneously to the long-horned katydids (now called TETTIGONIIDAE, or, wrongly, PHASGONURIDAE), and has been followed in this mistake by all continental European authors, till quite recently. There is, however, no doubt, that Linné, who adopted the name *Locusta* from the old Roman writers who applied it to swarming locusts, intended it to include those insects and the short-horned grasshoppers generally. This view was accepted long ago by British authors, and W. E. Leach (Edinburgh Encyclopaedia, ix, pt. 1, p. 120, 1815), though using *Locusta*, Geoffr., for katydids, used at the same time *Gryllus Locusta*, L., for *migratoria*, L., the latter being the only species described by him under this genus, and, therefore, he actually has fixed it as genotype of *Locusta*, L. A few years later on, Samouelle (Entomologist's Useful Compendium, p. 218, 1819) followed Leach in restricting the genus *Locusta* to *migratoria*, but he calls it wrongly *Locusta*, Leach, not Linné. Stephens in 1829 (Cat. Brit. Ins. i, p. 301, No. 2, sp. 3315) merely repeats Samouelle's interpretation of the genus. Even if we do not accept the genotype of *Locusta*, L., cited in 1815 by Leach, we shall find a most formal fixation of it in the British Entomology of Curtis (iii, pl. 608, August 1836), who in describing *Locusta christii*, Curtis (=*danica*, L.) said positively: "Type of the genus, *Gryllus migratorius*, L." All subsequent works on the same subject are, thus, of no importance, and the generic name *Pachytalus*, Fieber, proposed in 1853 (Lotos, iii, p. 121) for *migratoria* and *danica* is a pure synonym of *Locusta*, L. The proposal of Rehn (Canadian Entomologist, xxxiii, 1901) to restrict the genus *Locusta*, L., to *apricarius*, *viridulus* and *biguttulus*, which are included now in the genera *Stenocroderus* and *Omocestus*, as well as that of H. Krauss (Zool. Anz., xxv, 1902, p. 539), who regarded *tatarica*, L., as the genotype of *Locusta*, cannot be accepted in view of Curtis' work, which was overlooked by both these authors.

It is, therefore, in full accordance with what Linné meant by his genus *Gryllus Locusta*, as well as with the formal laws of nomenclature, that *migratoria*, L., must be regarded as the genotype of *Locusta*, L.\*

Not less than 16 "species" have been described by different authors as belonging to the genus *Locusta*, L. (= *Pachytulus*, Fieb.). This number, however, has been reduced already by earlier revisers, who synonymised many species; but W. F. Kirby in his Catalogue (Syn. Cat. Orth., iii, 1910, pp. 221-231) still mentioned seven distinct species. My investigations, however, have clearly demonstrated the variability of the species of *Locusta* to an extent far greater than might have been anticipated, and my conclusion, which will be fully proved presently, is that only two species can be distinguished, namely, *migratoria*, L., and *pardalina*, Walk., but the latter differs from *migratoria* in so many important characters that a new genus is described below (p. 162) to include it, which I propose to call *Locustana*, g. n.

### III. *LOCUSTA MIGRATORIA*, L., AND ITS FORMS.

#### Morphological Characters and Variability of *migratoria* and *danica*.

These two forms, if typical examples are studied, seem to be quite distinct from each other in many morphological characters, and may be regarded, as has been done by most authors, as two independent species. On the other hand, every extensive collection includes specimens of *Locusta* that cannot be identified with certainty with either *migratoria* or *danica*, but seem to represent intermediate forms. This fact induced many authors to regard *migratoria* and *danica* as but extreme individual aberrations of the same species.

In studying this question I tried, first of all, to analyse carefully and impartially† all the external morphological characters of both forms, as given by different authors, studying them on as extensive a series of specimens as possible.

After excluding all characters that at once proved to be too indefinite or simply incidental, the following summary of differences between typical *danica* and *migratoria* has been obtained:—

##### *L. migratoria* (fig. 1, C, D, E.)

*Vertex* convex, with a median longitudinal keel; fastigium separated from frontal ridge by an angular transverse keel.

*Pronotum* relatively shorter and broader in metazona, with a distinct constriction before the middle; fore margin rounded; hind angle rounded; median keel low, in profile straight or even concave.

*Elytra*‡ relatively longer.

*Hind femora* relatively shorter.

##### *L. danica* (fig. 1, A, B.)

*Vertex* flat, without median keel; no transverse keel separating fastigium from frontal ridge.

*Pronotum* relatively longer and more compressed laterally, without or with but feeble constriction before the middle; fore margin angulately prominent; hind angle acute; median keel high, tectiform, convex in profile.

*Elytra* relatively shorter.

*Hind femora* relatively longer.

\* I am much indebted to Mr. J. H. Durrant for the help he has generously given me in the solution of this question.

† I must candidly confess that when starting my work I had only a very modest intention—to find out characters for separating *migratoria* and *danica*, which I assumed beforehand to be distinct specifically. The facts quickly destroyed my preconceived opinion and compelled me to work deductively.

‡ This important and rather striking difference between *migratoria* and *danica* was first noted by the artist of the Zoological Museum in Petrograd, Miss O. M. Somina, who made drawings of both insects for Mr. I. Shevyrev, and the latter drew my attention to it.

A study of long series of both forms showed that the differences in the vertex, as given above, are quite unreliable, since the median keel of the fastigium proved to be absent in one per cent. of the specimens of *migratoria*, as well as in about 7 per cent. of *danica*; the transverse keel was found in 80 per cent. of *migratoria* and in about 47 per cent. of *danica*; as for the flatness or convexity of the vertex, it is too indefinite a character to be reliable. The only trustworthy characters are, therefore, the shape of the pronotum and the relative length of the elytra and hind femora. In order to avoid, as far as possible, any subjective judgment, I have expressed these characters in terms of actual measurements. This is quite simple in the case of the elytra and femora, since there exists an inverse proportion between their lengths, and we may simply express the length of the femora as a percentage

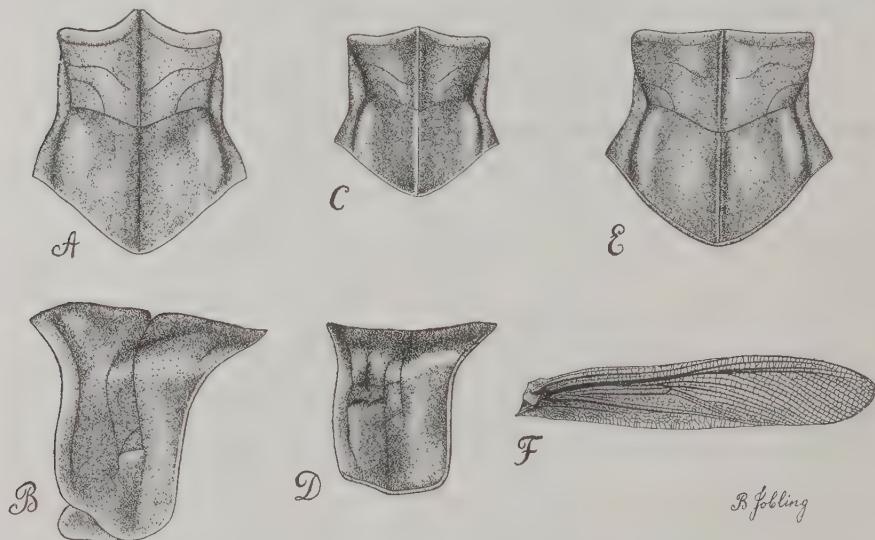


Fig. 1. *Locusta migratoria*, L. : A, B, phase *danica*, L., ♀, Turkestan ; C, D, ph. *migratoria* ♂, progeny of preceding specimen ; E, ph. *migratoria*, typical ♀, Astrakhan ; F, elytron. Elytron natural size, remainder  $\times 3$ .

of the length of the elytra. As for the shape of the pronotum, numerous measurements have shown that the width of the metazona (measured between the shoulders, i.e., at its widest), if expressed as a percentage of the length of the whole pronotum (along the median keel), gives the best and most reliable impression of the actual shape. The relative height and form of the median keel, which seem to be excluded from consideration by using this proportion, is but a secondary character which depends entirely on the relative length and width of the pronotum. If we imagine that the short and broad pronotum of *migratoria* undergoes a lateral compression, we may expect it to become longer, and its median keel higher and convex, especially in the metazona, which should be most influenced by lateral compression ; there is no doubt, therefore, that the shape of the median keel must be, and actually is, subject to changes correlated with those of the length and width of the whole pronotum.

Though it would be interesting and useful to give individual dimensions of all the specimens measured, I refrain from doing so in order not to encumber this paper with many pages of figures. I will give, therefore, only a general table of the chief results obtained, which will be enough for our conclusions (see Table I.).

TABLE I.

Showing Dimensions of different Phases of *L. migratoria*, *L.*

	Number of Specimens Examined.				Pronotal Proportion.*				Femoral Proportion.†			
	Total.	<i>migratoria</i> .	<i>danica</i> .	transitional.	Maximum.	Minimum.	Extent of Variation.	Average.	Maximum.	Minimum.	Extent of Variation.	Average.
1. All <i>migratoria</i> .. .. ..	171	171	—	—	0.89	0.71	0.18	0.80	0.53	0.40	0.13	0.46
2. All <i>danica</i> .. .. ..	166	—	166	—	0.85	0.59	0.26	0.72	0.63	0.43	0.20	0.53
3. Palaearctic <i>danica</i> .. .. ..	103	—	103	—	0.84	0.59	0.25	0.72	0.63	0.43	0.20	0.52
4. Extra-Palaearctic <i>danica</i> .. .. ..	63	—	63	—	0.85	0.66	0.19	0.74	0.60	0.46	0.14	0.55
5. Stavropol province, 1912 .. .. ..	25	25	—	—	0.87	0.71	0.16	0.79	0.53	0.42	0.11	0.45
6. do. do. 1913 .. .. ..	32	19	8	5	0.87	0.66	0.21	0.77	0.53	0.41	0.12	0.47
7. Valley of R. Kuma, 1913 .. .. ..	28	23	4	1	0.87	0.64	0.23	0.78	0.53	0.41	0.12	0.46
8. do. 1914 .. .. ..	36	25	8	3	0.87	0.65	0.22	0.76	0.54	0.42	0.12	0.48
9. Lac Vshivoiye, 1912 .. .. ..	11	10	1	—	0.80	0.74	0.06	0.78	0.48	0.41	0.07	0.45
10. do. 1913 .. .. ..	8	2	4	2	0.80	0.69	0.11	0.75	0.51	0.48	0.03	0.49
11. Konstantinovka, Stavropol prov. 1911 .. .. ..	10	—	6	4	0.77	0.68	0.09	0.72	0.55	0.45	0.10	0.50
12. Kalaus, Stavropol prov., 1913 .. .. ..	9	7	—	2	0.89	0.73	0.16	0.79	0.49	0.45	0.04	0.47
13. Valley of R. Terek, 1913 .. .. ..	26	22	—	4	0.87	0.76	0.11	0.80	0.50	0.42	0.08	0.46
14. Valley of R. Syr-Darya, 1912 .. .. ..	16	16	—	—	0.89	0.74	0.15	0.80	0.50	0.40	0.10	0.45
15. Mangishlak, Caspian Sea, 1911 .. .. ..	10	10	—	—	0.87	0.73	0.14	0.80	0.46	0.43	0.03	0.45
16. Korea, 1900 .. .. ..	8	—	8	—	0.78	0.68	0.10	0.73	0.60	0.52	0.08	0.55
17. Smyrna .. .. ..	14	—	14	—	0.84	0.67	0.17	0.75	0.63	0.51	0.12	0.55
18. Azores .. .. ..	20	—	20	—	0.85	0.69	0.16	0.75	0.60	0.52	0.12	0.57
19. Congo .. .. ..	9	—	9	—	0.82	0.68	0.14	0.75	0.59	0.50	0.09	0.54
20. S.W. Nyasa .. .. ..	4	—	—	—	0.94	0.83	0.11	0.86	0.46	0.42	0.04	0.44
21. Lagos .. .. ..	5	—	—	—	0.85	0.78	0.07	0.86	0.46	0.42	0.04	0.44

\* Relation of the shoulder width to the length of pronotum.

† Relation of the length of hind femur to that of the elytron.

When studying the first two lines of the table we see that individual figures for specimens of both forms are highly variable. Owing to this variability there is no interval between a row of figures for *danica* and that for *migratoria*, which partly overlap each other. This accounts for the fact that a curve representing the variability of the pronotal proportion (fig. 2) in both forms together has only one maximum; it seems to indicate that, so far as the shape of the pronotum is concerned, there is no possibility of regarding *migratoria* and *danica* as different species, or even as two distinct forms of the same species. The curve of variability of the femoral proportion (fig. 3), on the contrary, has two separate maxima, as if the material studied could be divided into two distinct groups, be these species or units of lower taxonomic value.

As for the average figures for both forms, they are also quite distinct and even not too near each other; the maxima and minima are also more or less characteristic for each form. It may be noted that *danica* is more variable than *migratoria*, the extent of variation in it amounting to 35 per cent. of the average figure in the case of the pronotal proportion and about 38 per cent. for the femoral; while the corresponding variations in *migratoria* are only about 29 and 26 per cent. respectively. The next interesting point is that specimens of *danica* from the Palaearctic region are far more variable than those of extra-Palaearctic origin.

All subsequent lines in the table (from the fifth downwards) give figures each for a number of specimens from one locality and taken mostly at the same time, without any selection, and regardless of the forms to which they belonged, in order to obtain an impression as to proportion of both forms and of the extension and direction of variability in each lot separately. We shall have to deal with these lines in more

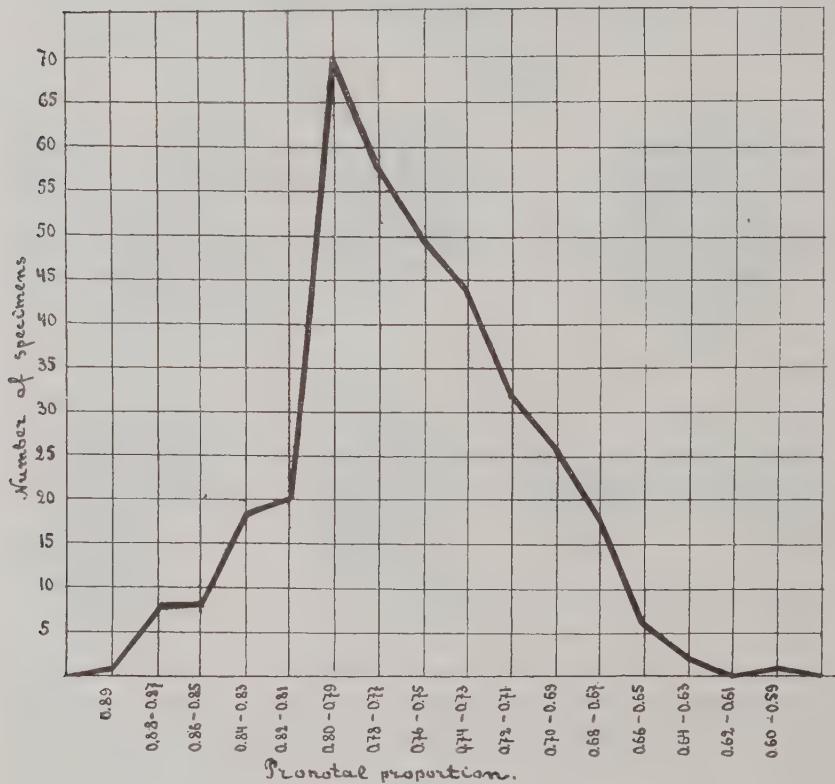


Fig. 2. Diagram showing range of variation in the pronotal proportion in 358 specimens of *Locusta migratoria*, L.

detail afterwards, but it may be noted that the range of variation is rather different not only in series of different origin, but also in lots taken at the same place in two successive years, *i.e.*, from swarms which may be regarded as two successive generations. Examples of this kind will be found in lines 5 and 6, and 7 and 8, of Table I.

If we summarise the results of this attempt at a statistical study of the morphological interrelations between *migratoria* and *danica*, they seem to be rather contradictory,

or, anyway, do not help much towards a definite solution of the question whether these two forms are really distinct or not.

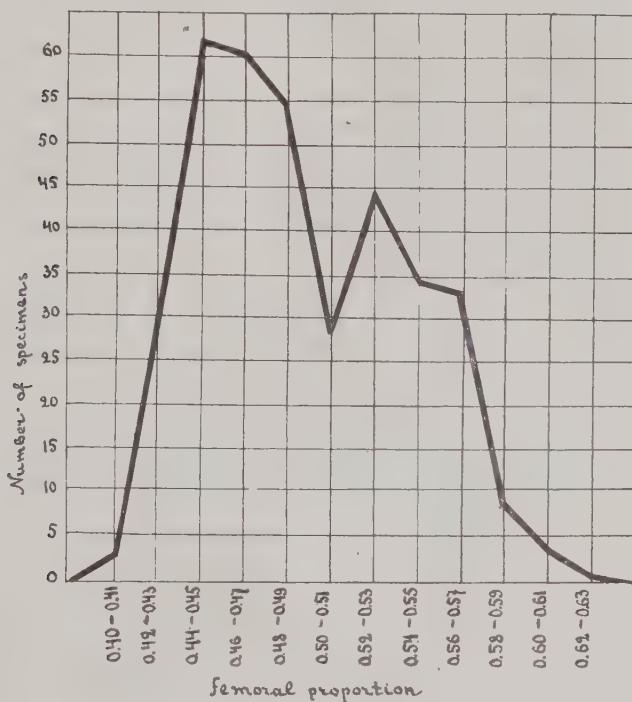


Fig. 3. Diagram showing range of variation of the femoral proportion in 358 specimens of *Locusta migratoria*, L.

#### Characters drawn from the Genitalia.

The late Dr. N. Adelung, of the Petrograd Zoological Museum, who tried long ago to solve the problem of *migratoria* and *danica*, suggested to me, when I began to work at it, that the anatomy of the genitalia, especially those of the males, might give definite proof of the specific difference of these insects, which he himself believed to be distinct. He even prepared some rough sketches of the male genitalia of both forms, which, in his opinion, showed that they may be separated without much difficulty by the shape of the penis. He gave up his work, but handed over to me his sketches and photographs. After a careful examination of these, and a comparison with several good preparations, I am fully convinced that Dr. Adelung's conclusion is not right; since the seeming difference between the penis in *migratoria* and *danica* in his preparations (so far as I know, he dissected only one specimen of each form) depends entirely on the fact that he studied the whole genital apparatus without dissecting it, and the somewhat different shapes shown in two of his drawings are merely the result of covering tissues having been more completely removed in one case than in the other.

My studies show, on the contrary, that the male genitalia of *danica* and *migratoria*, which are composed of several very complicated pieces (see fig. 7, A, B, C, D), are rather constant in the shape of the different parts, and though slight variations do occur, these are in no way connected with the external differences, and afford no reliable criterion for separating the two forms.

### Colour Characters in Adults and Larvae.

In regard to the general coloration, as well as the pattern of the different parts, adults of both *danica* and *migratoria* are rather variable, and no definite colour characters can be given for separating them. Generally speaking, however, the extent of the colour variability in *migratoria* is far less than in *danica*, and there is a well-marked tendency in the former to a paler general coloration and less defined markings; especially noteworthy is the fact that the hind tibiae in *migratoria* are never red, save quite exceptionally.

The coloration of *danica* is generally far more variable, with the evident prevalence of bright green forms; dark brown, even almost black forms occur also not infrequently, while the pattern is very variable but always well pronounced. The hind tibiae in *danica* are very often red, but this character is far from being constant, since often quite typical specimens have the hind tibiae pale or greenish.

While, as above stated, the coloration of the adults is of but very little use for separating the two forms, it is quite otherwise in the case of larval stages, in which there is a very striking difference. In fact, it is almost impossible to find any definite type of coloration of the larvae of *danica*, which vary enormously; uniformly green forms are most common, but fawn, grey, brown, and even black ones may be met with together. Quite the opposite is the case in *migratoria*, in which each larval stage exhibits quite constant colour characters. Their coloration presents a combination of black and orange-red (or yellow), the earlier stages being almost entirely black, while orange, or yellow, appears first in the third stage, extending gradually after each subsequent moult.\* There is, of course, a certain variability in the shade of the colours, but as a rule larvae of *migratoria* of the same stage are all practically identically coloured; and it is important to note that this type of coloration never occurs in the larvae of *danica* in spite of the wide range of variation in the latter.

### Sexual Dimorphism.

There is a well-pronounced sexual dimorphism of the general dimensions in *danica*, the males (adults) being distinctly smaller than the females; average figures of the length of the body, elytra, etc., for males differ from corresponding figures for females by about 20 per cent. of the latter, so that one may separate the sexes by the size only, provided that the specimens are all taken at the same place and time. As for the proportions between the dimensions of the different parts of the body, they are not connected with the absolute dimensions and remain the same in both sexes.

In *migratoria* no such apparent difference in size between the sexes is observed, the males being on the average smaller than the females by only some 4 per cent. of the figures for the latter; and males of larger size are indistinguishable from females so far as the dimensions are concerned. Since the absolute dimensions in both *migratoria* and *danica*, especially in the latter, are rather variable, they are of very little value for separating these forms.

\* I do not propose to give a detailed description of the larval stages of *migratoria*, since this has been done more than once by different authors; very good descriptions and fairly good coloured figures have been given by H. C. Pratt (Dept. of Agric. Feder. Malay States, Bull. No. 24, 1915).

Another case of sexual dimorphism is observed in the adults of *migratoria* during the period of copulation and concerns the general coloration.\* The males gradually assume a bright yellowish general coloration, most pronounced on the pronotum, while the females become more dull coloured, the pronotum turning to dark brown. These changes doubtless depend on some physiological processes connected with the maturation of the sex products. As for *danica*, it is not yet known whether it exhibits any change of coloration during adult life.

### Biology.

While *danica* seems to have no marked preference for any particular type of locality for its permanent habitation, except vast waterless tracts and forests, *migratoria*, on the contrary, has strictly defined permanent breeding grounds. In Russia, where much attention has been paid by entomologists to the biology of *migratoria*, its breeding grounds are all confined to the basins of the Caspian and Aral Seas and of Lake Balkhash, and more definitely to the deltas of the rivers discharging into them, namely, the Volga, Ural, Kuma, Terek, Arax, Syr-Darya, Amu-Darya, Ili, etc. These deltas, as a rule, extend over vast areas irrigated by numberless channels which change their course almost every year, some of them forming temporary pools and small lakes. The shores of these channels and even the beds of the shallower ones, as well as all the less elevated portions of land separating the channels from each other, are covered with a dense growth of the gigantic cane, or reed grass (*Phragmites communis*, Trin.), sometimes 10–15 feet high, which form almost impenetrable jungles extending over hundreds of square miles. These reed-beds, however, are not uninterrupted, since many of the islands between the channels are more elevated above the level of the water than is suitable for the growth of the reeds, which require a very damp soil. The soil of such islands mostly contains a large proportion of sand, and a peculiar flora of low, not very dense, mesophilous and xerophilous grasses covers them. It is in such localities that *migratoria* lays its eggs, as a rule,† while its larval swarms wander all over the valley, penetrating through the reed-beds, and even swimming across the streams. The leaves of the reeds, which contain a very large percentage of silica, represent the most preferred food of the larvae. The climatic conditions in these reed-beds are very peculiar and differ very much from those prevailing in the adjoining steppes and deserts; since the waters of the river are there spread over a vast surface, the evaporation is very extensive, and the damp, hot air amidst the reeds at midday vividly recalls the tropics.

All the sufficiently investigated breeding grounds of *migratoria* in Russia are of the character described, and nowhere except in these grounds does this insect live and breed permanently. Naturally the locusts are not always equally numerous in the breeding regions, and in the years of minimum development only a few swarms or even but single individuals may be found; during the next few years their number increases, the swarms become more and more dense, and a maximum is in this way attained.

The newly-hatched larvae collect in small groups, each of which is, as a rule, formed by larvae hatched from one egg-mass. These groups soon begin to move irregularly to and fro; if two groups meet they form one larger group and in this way larval swarms are formed, and their movements become more and more regular. Most authors regard want of food as the direct cause of these movements, but this explanation is entirely wrong, at least so far as concerns *Locusta migratoria* and

\* This fact was first observed by my assistant, Mr. Th. Gliniuk, in 1912, in Stavropol province, and was recorded by me in the paper: "The Fight against Locusts in the Government of Stavropol in the years 1907–1912," St. Petersburg, 1913 (in Russian).

† The matter is really more complicated than this, since the selection of spots for oviposition is usually closely connected with the more minute character of the soil and vegetation.

*Dociostaurus maroccanus*, Thunbg., both of which I have studied for several years. It is true that when the vegetation is very rich, the rapidity and extent of movement of larval swarms is less than in the case of a sparse vegetation, but larvae *will* move, however densely overgrown with their most favourable food-plants the place may be. Moreover, in both the species referred to, the larvae do not feed during movement, save in some exceptional cases, as, for instance, when a swarm has previously wandered for a long time over barren ground and then comes across a field of corn or other rich vegetation. My observations, though far from being complete, leave no doubt that a factor of utmost importance in the movement of larval swarms is temperature, and the following outline of the daily regime of a swarm will help to explain this.

It is a well-known fact that larval swarms do not move at all during the night, which they pass on plants in a semi-comatose state, caused doubtless by the low temperature. The first rays of the rising sun bring the larvae back to active life, and they begin at once to feed. The hotter the temperature grows, the more active become the insects, and soon they one by one jump or crawl down to the ground, where they continue to move about, now crawling, now jumping, as if feeling uneasy. Each larva in doing so disturbs its fellows, which leads to still more rapid general movement; this is at first entirely irregular, but sooner or later, through mutual influence, a common direction of movement is found and the swarm begins its day's march. So far as our observations in the Northern Caucasus go, the average temperature causing the first movements of the larvae lies near 13-15° C. In ordinary circumstances, *i.e.*, provided the sun shines all day and no unusual changes of weather occur, swarms keep moving the whole day, and as a rule do not feed when they move.\* In the afternoon, when the temperature begins to fall, the velocity of the movement decreases until, in the evening, the swarm stops; it is very interesting to note that this evening cessation of movement occurs when the temperature is again near 13-15° C. One by one the larvae crawl up plants and begin to take their evening meal. There is no doubt that swarms do not choose their resting places, but simply stop where they are overtaken by the critical temperature. I have seen many swarms which have stopped for the night at entirely barren spots just after they have crossed a strip with abundant vegetation, or only a few yards before reaching it.

Such is the behaviour of larval swarms of *migratoria* under ordinary conditions of weather, and all my observations lead me to the definite conclusion that their movement has nothing to do with hunger and depends entirely on thermotropism (probably negative), and on another, as yet little known, tropism which is displayed by the tendency of each larva to repeat the movements of its nearest fellows and to move in the same direction as they do.†

The behaviour of larval swarms under abnormal conditions of weather lends further support to this conclusion. If the day is colder than usual and the temperature does not rise above 15° C., the swarm remains and feeds all day where it spent the night. If the temperature falls during a normally hot day, the swarm stops long before its usual time. Especially interesting and instructive is the following example: if a swarm is moving at the temperature in sunshine not much above the critical point and the sun is temporarily hidden behind a cloud, so that the temperature falls below that point, the swarm stops, or in any case its movement

\* I intentionally avoid discussing here the question of the direction of movements and its causes, since it is very complicated, and besides, it has no direct connection with the chief problem we are now investigating; one point, however, is worth mentioning: that the direction of movement has, as a rule, nothing to do with the looking for food, since, for one thing, larvae do not feed during the day, and they often move from fertile spots into entirely barren places.

† This kind of tropism is not uncommon among other insects, and even vertebrates; a herd of cattle will afford excellent examples of it.

becomes slower and less defined ; as soon as the cloud has passed and the sun shines again, the swarms starts its march afresh ; even small clouds hiding the sun just for a few minutes produce the same effect.

There is likewise an upper limit of temperature that causes the cessation of movement ; and on very hot, close days swarms often stop their march during midday ; in that case, however, the larvae do not climb plants to feed but collect in close clusters under the plants, evidently hiding from the direct rays of the sun. This being a more rare phenomenon, I have no precise data as to the exact temperature at which it occurs, but anyhow it gives additional support to my theory that the movements of larval swarms depend primarily on thermotropism.\*

After the final moult the wanderings of swarms on foot naturally cease, though when the majority of a swarm is in the last larval stage and only single individuals become winged, the latter may often be seen crawling and jumping with the swarm.

A few days after the last moult, newly-winged insects are incapable of long flight, their elytra and wings being not yet hard enough. This period is passed by swarms in the same spot, devouring vast quantities of food, and it is a very favourable (and also the last) opportunity for their destruction by spraying.

When locusts are fit for flight, single individuals begin to take wing and fly for a short distance, often circling above the still sitting swarm. Whenever a locust flies near enough to another that is at rest, the latter is disturbed and often takes wing and flies in the same direction ; this is again a manifestation of the same tropism which causes the movement of larval swarms. The larger the number of individuals with fully developed wings, the more often do they take these short flights, and the more other locusts join them, disturbing yet others when circling above the swarm. It is easy to understand that this must necessarily result, sooner or later, in the whole swarm taking wing. During the first movements no definite direction of flight is apparent, but since each individual tries to follow its nearest fellow, a common direction of flight must necessarily result. During the first few days these flights are rather irregular, and swarms do not assume a definite direction, but simply circle above their breeding grounds. If two swarms meet, they mix together, and so the swarm gradually grows larger and larger. The larger the swarms grow, the more regular and the longer become their flights, and at last the time comes when they assume a definite direction, and the insects take leave of their breeding region altogether ; then only few scattered swarms remain where just a day or two before locusts were numberless. In fact this emigration from the breeding regions is often so complete that only single individuals are left behind, and those prove to be nearly all parasitised by the larvae of Sarcophagid flies, or by red mites (*Trombidium*).

What is the cause of this emigration ? The generally accepted theory is that locusts migrate from want of food. I have already proved that this is not the case in the larval swarms, and as for flyers, the very idea of locusts being compelled to emigrate from breeding regions by the lack of food could never occur to anyone who has seen these vast areas overgrown with luxurious vegetation of a kind most acceptable to locusts. In fact, swarms always leave behind them immense feeding grounds and emigrate sometimes to almost vegetationless deserts, which, as a rule, adjoin the permanent breeding areas of *migratoria*.

\* The habits of the larval swarms of *migratoria* are well known to those concerned with locust control in Russia, and as the insects are now almost exclusively destroyed by spraying with arsenical insecticides, which are of use only when the actual food of the larvae is poisoned before feeding, no spraying is done during day, when swarms are in movement. The daily work is usually divided into two periods, and spraying is done in the early morning, before the larvae begin to go down from the plants, and in the evening ; the evening work begins before the swarms stop for the night, since it is always easy to reckon where a certain swarm will stop, and the spraying is continued till it is quite dark ; this evening spraying is the more effective. In cool weather, when swarms do not move, work goes on all day continuously.

Still more unacceptable becomes the theory of emigration being caused by lack of food, if we turn our attention to certain physiological changes which locusts undergo during the period of emigration. When dissecting individuals taken from emigrating swarms, it will be found that by far the greater portion of the inner cavity of the body is occupied by air-sacs, described long ago by American entomologists in the Rocky Mountain locust, and occurring doubtless in all other migrating species of locusts. These air-sacs are only temporary organs, reaching their highest development at the period of emigration and disappearing towards the end of that period, when the developing reproductive organs take their place. During the emigration, however, the air-sacs are enormously large and all the other internal organs are much compressed, including the stomach, thus rendering the insect almost incapable of taking food, at any rate in large quantities. This assumption, based upon anatomical facts, is supported also by field observations; for, in fact, the emigrating swarms, when they stop their flight, do not feed much, though incidentally they may cause great damage by merely cutting the stems of cultivated plants.

Further anatomical researches reveal also the fact that the fat-body is more developed in insects just before and at the beginning of emigration, and is almost exhausted towards the end of it; probably locusts during this period live essentially on the food reserves in the fat-body, being unable to take much vegetable nourishment and consequently scarcity or even lack of food has nothing to do with the emigration.

A Russian entomologist, K. N. Rossikov, called attention to another possible explanation of the emigration of *migratoria* from its breeding grounds. He believed it to be an immediate result of the activity of the parasites of the adult locusts, *i.e.*, Sarcophagid larvae and red mites; he believed that the parasitised individuals become restless and try to get rid of their parasites by flight. If this were so, the result would be that only parasitised individuals would emigrate and all the non-parasitised would remain behind in the breeding grounds, though actually just the opposite is observed. This theory, therefore, is as groundless as the previous one.

One more theory is that emigration might be regarded as a tendency of the species to avoid overpopulation of a breeding region and to find new suitable breeding grounds. As for the possibility of overpopulation of breeding regions of *migratoria*, this idea is simply absurd, since these regions are vast enough to harbour many hundred times more locust swarms than there are in years of maximal development.

To investigate the presumption that swarms are emigrating to look for new breeding grounds we must see what is the fate of swarms after they have left their permanent breeding regions.

As far as is known at present, a swarm of emigrating locusts usually covers a very long distance at one flight; if sometimes it settles down on its way (and this is often caused by unfavourable conditions of weather), it soon resumes its flight again. I will not discuss here the question of the direction of the flight and its probable causes, since but very little is known about it. One fact, however, is firmly established and is of great importance for our immediate purpose: it is that in the majority of cases the swarms maintain throughout the same more or less defined direction which they assumed when starting; of course, a strong wind or other incidental circumstances may to a certain extent alter this direction.

This straight flight, aimless and causeless as it seems, does not last long, though a swarm may cover during it very long distances, the velocity of flight being far greater than might be expected.

Sooner or later, the regularity of the flight seems to be lost; swarms begin now to settle down, then take wing again and circle about; they begin also to eat more, since their air-sacs have grown smaller and the fat-body is also exhausted. I believe,

therefore, that the cessation of flight is caused entirely by these two purely physiological phenomena, and it is obvious that no possibility exists for swarms to look for suitable new breeding grounds ; they merely settle down wherever they are compelled to do so by their physiological condition, quite irrespective of the character of the locality. This may occur accidentally near some suitable spot, and there is also the probability that the swarm would find one during the irregular circular flights which take place at the end of the emigration and precede pairing and oviposition ; but the extent of these flights is rather limited and this probability is correspondingly small. Theoretically it is far more probable that the cessation of emigration would become necessary in a locality quite unlike the normal breeding grounds.

A typical and very convincing example of this kind was observed in Stavropol province in the autumn of 1912, when numerous large swarms of *migratoria* emigrating from the breeding area at the mouth of the river Terek invaded that province. One or two of these swarms settled down in the lower portion of the valley of the river Kuma, which is itself a breeding region of the same locust, but was in that particular year free from the local swarms ; the Terek swarms consequently found there most favourable conditions and oviposition took place in the normal manner. Practically all the other invading swarms stopped their flight in the steppe adjoining the middle course of the Kuma, some of them on the very border of the valley. Now this part of the valley presents some very suitable breeding grounds, which have often played an important part as the source of invasions in Stavropol province. Several of the swarms visited these grounds more than once during their circular flights, which are often supposed to serve the purpose of finding suitable places for oviposition. Ultimately, however, only a small number of scattered locusts oviposited there, while all the swarms deposited their egg-masses in the dry steppe, where the conditions of soil and vegetation are entirely different from those in normal breeding grounds. It is especially interesting to note that some of the eggs were laid on a portion of the steppe sloping towards the valley of the river, *i.e.*, in the closest proximity to the above-mentioned suitable area.

This latter fact and a study of the general conditions under which oviposition took place clearly show that nothing in the least like a conscious (or instinctive—the exact word does not matter in this case) choice of suitable places by swarms can be assumed. There is, however, one exception : when a swarm settles down for oviposition, and the females, after several attempts to penetrate the soil, find it too hard, they become restless, take wing again, and after a few rounds settle down at another spot. Thus we must conclude that oviposition takes place whenever the majority of females are ready for it, and quite irrespective of the suitability of the conditions for the next generation, provided that oviposition is physically possible.

In conclusion, the theory that emigration has as its aim the finding of new breeding places is also groundless, and there is at present no possibility of explaining the emigration by any causes except physiological ones : the development of the air-sacs compels the insects to fly, and this impulse is strengthened by their gregariousness, that is by some kind of tropism which makes each individual keep close to its fellows and follow their movements. Later on we shall see what is the biological meaning of the emigration.

Such is, briefly, the life-cycle of *migratoria*. The biology of the larvae and adults of *danica* is only very insufficiently known,\* but what is known shows that their behaviour is entirely different from that of *migratoria*. The chief biological feature of the latter in both larval and adult stages—gregariousness—is quite absent in *danica*. This is especially striking in the larvae ; if a wandering swarm of *migratoria*

\* This is directly due to the fact that most entomologists have regarded *danica* as distinct from *migratoria* and as being an entirely harmless species, so that the study of its habits has been neglected.

larvae comes across a solitary specimen of the same form, the latter immediately joins the movement, but when a larva of *danica* is overtaken by a swarm of *migratoria*, it tries to escape by leaps as quickly as it can. At the same time, the larvae of *danica* seem to possess thermotropism of the same kind as that exhibited by *migratoria*, their time of feeding being restricted to the evening and early morning, while during the day they are probably also on the move, though I have no reliable observations on this point. As for the adults of *danica*, the only point of their biology that we know for certain is that they do not form swarms and hardly migrate at all; a study of their behaviour, as well as of their anatomy (air-sacs) is of the greatest importance for the solution of the whole problem.

Some very interesting indications of further biological differences between *danica* and *migratoria* have been obtained at the Turkestan Entomological Station by V. Plotnikov in his breeding experiments.\* This entomologist obtained from typical individuals of *danica*, kept in the laboratory, a second generation of larvae in only 16-30 days after oviposition, instead of in the following spring as is usually the case with *migratoria*. In one particular experiment even three generations were bred in one year. That this unusually short period of hatching was not due to the unnatural conditions of the experiment is shown by the fact that eggs laid in the same laboratory by individuals of *migratoria* did not hatch before the following spring. Dissections of eggs showed that the development of the embryo begins in eggs of both *migratoria* and *danica* shortly after oviposition; but in the case of *migratoria*, when the embryo reaches a rather advanced stage, development is suspended for several months, corresponding to the period of hibernation, though in the laboratory there is no change in the conditions to account for this. At the same time and under exactly the same conditions, the embryos in eggs of *danica* develop without any interruption. These experiments suggest an explanation of the fact that, while the larval stages of *migratoria* may be found only in spring and the beginning of summer and the adults during the summer and autumn, there is no such strict regularity about the occurrence of the stages in *danica*, though many eggs of this form probably hibernate as well.

#### Field Observations on the Transformation of *migratoria* into *danica*.

During the great invasion of locust swarms which occurred in the Stavropol province in the autumn of 1912 (see p. 147), I used the opportunity for studying, from the systematist's standpoint, as large a series of specimens as possible. All the insects collected, which were taken from the swarms without any selection and amounted to many hundreds, proved to be quite typical *migratoria*. Nothing in the least like *danica* was observed in field, either by myself or by my assistants, whom I had previously instructed to look out for all aberrant forms and who knew *danica* perfectly well; the number of individuals thus studied without collecting them is difficult to estimate, but it doubtless amounted to many thousands. I believe, therefore, that I am right in assuming that the swarms consisted purely of *migratoria*, and that *danica*, or even intermediate forms, were entirely absent. The measurements of the specimens from those swarms are given in the fifth line of Table I (p. 139), and the following conclusions may be drawn from them: the specimens are rather uniform, the extent of their variability (0.16) being less than the average for *migratoria* (0.18—see line 1); the average figures for the pronotal (0.79) and the femoral (0.45) proportions are extremely near to the average for *migratoria* (0.80 and 0.46, respectively). The colour characters, though not very reliable, were very constant, which is not the case in *danica*. If we consider also that the locusts kept in close swarms which had no tendency to disperse, we must conclude that the swarms were formed exclusively by typical individuals of *migratoria*.

\* Report on the work of the Turkestan Entomological Station in 1912, 1913, 1914, and part of 1915; pp. 28, 55-59; Tashkent, 1915 (in Russian); see also Rev. Appl. Entom., iv, p. 211.

According to the routine of the control work adopted in Russia, all the swarms were closely watched during their wanderings by the trained staff, and all the spots where oviposition took place were marked out and also noted on the maps. Owing to this procedure there was no doubt that in the following spring we had to conduct the destruction work against the immediate progeny of those swarms. As soon as the larvae in 1913 reached their third stage, when differences between *migratoria* and *danica* are more apparent than in the earlier stages, it became evident that although the bulk of the larval swarms consisted of *migratoria*, there were many individuals which were certainly *danica*, these being different in coloration and showing a tendency to desert the swarms. In spite of the intensive control measures, several small swarms escaped destruction and attained their final moult; these adult specimens proved to be rather different from those of their parental swarms (see line 6 of the table, p. 139). A rather large admixture of typical *danica* was very obvious, but still more numerous were specimens of an intermediate character which could not be identified either with *danica* or with *migratoria*; the bulk of the insects, however, might have been referred to *migratoria*, but showed an obvious inclination towards *danica*, in fact they had the pronotum more compressed laterally, the median keel more raised, the elytra longer and the femora relatively shorter, than in the specimens from the parental swarms; their coloration was also more variable. The proportions are especially instructive when compared with those for the swarms of 1912; in studying these figures one may see that the extent of variation was far larger than in 1912, and the average figures also changed in the direction of *danica*. The swarms were not so dense as in 1912, and the individual insects showed obviously less developed gregarious habits; numerous single individuals of *danica* were scattered all over the steppe, without any connection with the swarms; the latter did not undertake any migrations and gradually dispersed.

Similar, though less striking examples are given in lines 7 and 8, 9 and 10 of the table, in compiling which precautions were also taken to obtain the series most likely to represent two successive generations. Unfortunately, I could not secure reliable examples of more than two such generations from one spot.

#### Breeding Experiments by V. Plotnikov.

Though field observations like those described above are of great value, they have the disadvantage of not affording absolute proof, and the only way to obtain this is by breeding experiments. Such experiments have been undertaken by my friend V. Plotnikov, in Tashkent, and, though conducted on a very moderate scale, have yielded some most interesting and valuable results. Since all the actual specimens from these experiments were given to me by V. Plotnikov, and are before me now, I am able to give a little more detailed account of the results than were recorded in his original communication.

In the summer of 1913 several specimens of both sexes of very typical *danica* were isolated in cages, in which copulation and oviposition took place; the eggs hatched without hibernation, as is not uncommon with *danica*, but so far as we know never occurs in *migratoria*. The description of the larvae and adults bred from them is given by V. Plotnikov, as follows:—

“ The larvae had in the first stage a dark grey coloration, and not black as in *migratoria*. In later stages they acquired various colorations—uniformly green, dark grey or brownish—but a number of them had the typical colouring of *migratoria*, namely, a general reddish brown colour (sometimes greenish), with velvety black stripes (broad or narrow) along the sides of the pronotal keel and black stripes on the sides of the abdomen. The adults presented no characters typical of *danica*; the profile of the pronotal keel was usually straight, sometimes even concave. The males were, however, smaller than the females.”

After studying the specimens, I can only confirm Plotnikov's statement that while the parents are all very typical *danica*, save that not all of them have the hind tibiae red (which character is not quite constant in that form), their direct offspring are on the contrary all well-defined *migratoria*, though a few of them have the tibiae red, as is sometimes the case in this form. One of the parents and one of the off-spring are figured above (fig. 1, A, B, C, & D).

Another experiment is described by V. Plotnikov, as follows:—

"In 1914 I bred from egg-masses sent from Amu-Darya district\* *P. migratorius*, and from egg-masses deposited by these insects I bred in the spring of 1915 again *migratorius*. On the 19th June I found in the soil of the breeding cage, where these individuals (now mature) used to live, five egg-masses, which I transplanted carefully into the soil of another cage; there, on the 6th August, *i.e.*, more than 48 days after the oviposition, a single larva hatched, a female of dark grey coloration; the rest of eggs in the egg-masses remained with an half-developed (hibernating) embryo. When in its second stage, this larva acquired a green coloration, which it retained till the fifth (final) stage. The profile of its pronotal keel was convex. . . . The adult insect retained the convex keel of the pronotum; its body was green, the elytra light brown, and its hind tibiae turned red."

This specimen is before me now, and I can only confirm V. Plotnikov's opinion that it represents the most typical *danica*. As for its actual parents they possess all the essential characters of *migratoria* very well defined, and no one could hesitate to identify them with that form. Unfortunately the experiments were discontinued upon Plotnikov's joining the army.

V. Plotnikov's conclusion from his experiments is as follows: ". . . it is impossible to separate *P. migratorius* and *P. danicus* by any characters; characters of *danicus* (including its capacity to produce a second generation) are expressed in the latter species more strongly. It is possible to suppose that this species is now in the process of splitting off from the primitive species, *P. migratorius*."

My own conclusions differ somewhat from this, but I shall come to them later on. All that I shall point out now is that these experiments prove finally the possibility of the actual breeding of *migratoria* from *danica* and *vice versa*; my field observations on the same subject give evidence that it may occur not under laboratory conditions only, but in nature as well. On the other hand, we must not forget the numerous differences between them, especially the biological ones, which prevent us from regarding *danica* as a mere synonym of *migratoria*. It is evident that they must be regarded as two different forms of the same species without, in the meantime, any more precise definition of their systematic value.

#### **Locusta migratorioides**, Rch. & Fm.

This insect was described from specimens from Abyssinia; later on, Saussure and other authors recorded it from many tropical localities. In its morphological features it is very much like *migratoria*, while its difference from *danica* is far more marked than in the latter. From *migratoria* it differs only in the following characters:—The pronotum (fig. 4) is still more constricted before the middle; its median keel very low, often concave in profile; fore margin almost straight; hind margin very widely rounded; the shoulder width almost equal to the length of the pronotum, the average pronotal proportion being 0.86, while it is 0.80 in *migratoria*; the elytra relatively longer and the hind femora shorter, which results in the femoral proportion being on the average 0.44, as against 0.46 in *migratoria* (see Table I, lines 20 & 21).

\* A permanent breeding region of *L. migratoria*.—B.U.

It is quite obvious from this definition that *migratorioides* presents no new features as compared with *migratoria*, but it seems to be in all the chief characters merely a further modification of *migratoria* in the direction opposite to *danica*. Unfortunately the material of *migratorioides* now at my disposal is rather scanty, and the extent of its variability remains uncertain. Still, there is in the British Museum one female taken at Sarkwalla, Northern Territories, Gold Coast, 4 7.xi.1915 (Dr. J. J. Simpson), which is in all respects intermediate between *migratoria* and *migratorioides*.

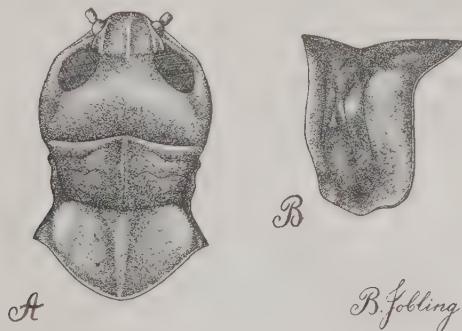


Fig. 4. *Locusta migratoria*, ph. *migratorioides*, Rch. & Frm., ♂ from Lagos : A, head and pronotum from above ; B, pronotum, side view ( $\times 3$ ).

The study of the male genitalia of *migratorioides* reveals no difference whatever from the structure observed in *danica* and *migratoria* (fig. 7).

As for the coloration of the larval stages, we have a good description of them given by H. C. Pratt (*l.c.*) and from it, as well as from the study of the actual specimens sent by Mr. Pratt to me in 1913, I was unable to find any reliable difference between them and the larvae of *migratoria*.

On the other hand, Mr. Pratt says in his paper that the coloration of the larvae is not very constant and the green individuals occur alongside with the typically coloured ones. The figures of the green and black adults given in his paper (*l.c.*, pl. XIV) certainly represent *danica*. This is, then, an indication that the same interrelation exists between *migratorioides* and *danica* as has been proved positively for *migratoria* and *danica*. A confirmation of the same fact I received not long ago, when several specimens of locusts were sent from North Borneo to the Imperial Bureau of Entomology for identification. They all proved to be *migratorioides*, but as the lot was rather small, the Bureau asked for more material, and after several months a new collection arrived, with a note that the specimens were taken singly at the same spot as the swarms from which the first lot had been collected, and represented the actual offspring of those swarms. All specimens in this second lot are quite typical *danica*.

One more example of the transformation of *migratorioides* into *danica* I have found in Dr. La Baume's paper on the African locusts.\* In a reference to Dr. L. Sander's book† he discusses an invasion of locusts which took place at Misahöhe, Togo, in December 1893, while in March 1894 new larval swarms appeared at the same locality, which Dr. Sander believed to be the direct progeny of the December swarms.

\* Die Afrikanischen Wanderheuschrecken.—Beih. zum Tropenpflanzer, xi, No. 2, 1910, p. 82, footnote 22.

† Die Wanderheuschrecken und ihre Bekämpfung in unseren Afrikanischen Kolonien. Berlin, 1902.

These latter consisted, as Dr. La Baume stated after a study of the specimens, of *migratorioides*, while the March swarms, again according to his determination, were composed of *danica*, which leads him to the conclusion that they could not possibly be the direct progeny of the December swarms. I believe, however, that Dr. Sander (who simply did not distinguish *migratorioides* from *danica*) was right, and that the December swarms of *migratorioides* actually produced the March swarms of *danica*.

All these facts, of course, do not furnish us with absolute proof of the transformation of *migratorioides* into *danica*; but since such a transformation is firmly established for *migratoria* and *danica*, I feel justified in assuming it to be true in this case also.

### Geographical Distribution.

Of the three forms here dealt with, *danica* has the most extensive range; in fact, it is found throughout the whole of the Eastern hemisphere, except the coldest regions beyond 60° northern and southern latitude, very high mountains\* and vast waterless deserts. As for the Western hemisphere, though many books state that *danica* occurs in America, I know of no reliable evidence to this effect, and am fully convinced that all the older records are due to mistakes, either in labelling the specimens or in their identification.\*\* Thus, F. Walker described *Pachytalus brasiliensis*, which is conspecific with *danica*, from a specimen in an unlabelled collection which included insects not from Brazil only, but from other parts of the world also, and the mistake in locality in this case is beyond doubt.

A form with such an enormous area of distribution may be expected to present some geographical variations, and in fact, apart from the individual variability which, as I have already stated, is very great in *danica*, some more constant variations, probably connected with geographical conditions, are also observed. Thus Australian and New Zealand specimens are rather small on the average, with a comparatively short pronotum and the wings slightly infumate; they have been described by Saussure as a distinct species, *Pachytalus australis*, Sauss. As, however, no one has yet studied extensive series of individuals of Australian origin, the constancy of these characters is not proved; on the other hand, specimens of the same kind occur incidentally in other localities as well, and their distinctions from the typical *danica* do not exceed the average extent of observed individual variability. Again, as I have already pointed out (p. 139), there is a slight difference between the individuals of *danica* from the Palaearctic region and those of tropical origin, which also may depend on geographical conditions; but in this case likewise more extensive investigations are wanted.

The area of distribution of *migratorioides*, though not so extensive as that of *danica*, still occupies the greater part of the latter, in fact the whole of it except the Palaearctic region.

The latter region is the home of *migratoria*, which is however common in its south-eastern parts only (especially in the basin of the Black, Caspian and Aral Seas and that of Lake Balkhash), where its permanent breeding grounds are, while its emigrating swarms penetrate much farther north and westwards, sometimes as far as Finland and England. On the other hand, single individuals, which agree in all their morphological characters with *migratoria*, occur far beyond the Palaearctic region as well. Thus, Brunner v. Wattenwyl recorded† *migratoria* from the Malay Archipelago (Batjan and Borneo). I have myself seen a quite typical specimen of

\* I have recorded (Revue Russe d'Entom., xiv, 1914, p. 232) this form from the Pamir upland as high up as 11,000 ft. above sea-level; there is in the British Museum a couple of specimens taken at Giangtse, Tibet, at an altitude of 13,000 ft.

\*\* Dr. J. Rehn, of Philadelphia, informed me recently that he is of the same opinion.

† Abh. Senkenberg. Naturf. Ges., xxiv, pp. 194, 196.

*migratoria* sent from Southern Celebes by Dr. Roepke to the Imperial Bureau of Entomology, which had the following note attached: "A Locustid from S. Celebes (Pangka djene) appearing there in small swarms and causing damage to the natives' plantations, such as rice, corn, etc."

### The Theory of Phases.

Though the above recorded facts by no means exhaust the points to be considered in connection with the problem of the interrelations of *migratoria*, *danica* and *migratorioides*, they yet permit us to make an attempt to find out the best explanation at present possible. The following theory seems to me to agree in a rather satisfactory manner with all the facts known at present, though some modifications of it may prove to be unavoidable when new data are available.

As a starting point, I take it as positively proved that the three forms cannot be separated specifically and that they represent taxonomic units of lower grade than the species, which must be called, according to the law of priority, *L. migratoria*, L. They are, however, quite distinct from each other, though connected by transitional forms.

What term, then, should be applied to them? They are certainly not mere individual aberrations—as they are often assumed to be by other authors—since they are rather constant in their average morphological characters and still more so in their biology; nor can we call them subspecies, *i.e.*, geographical races, as they are found together in the same locality; nor are they seasonal forms, since the transformation of one of them into the other has evidently nothing to do with season. The only more or less suitable term for them is "morpha," in the sense proposed by A. P. Semenov-Tjan-Shansky,\* who proposed to apply this name to such forms of a species that present a direct result of the immediate external influences on the individual insect during its development, and which therefore do not appear in succeeding generations if the original influence ceases. Under this definition come seasonal forms, which may be obtained by the artificial application to developing individuals of certain factors causing their appearance under natural conditions; the forms resulting from feeding larvae by some special food, etc. The same term may be applied, according to the personal opinion of A. P. Semenov-Tian-Shansky, expressed in his letters to me, to the case of the *Locusta* forms. It seems to me, however, that the term "morpha" is rather vague, and moreover we are yet far from knowing whether the transformation of one form into the other is due to some immediate external influence or to some yet unknown internal cause; I think, therefore, that the term "phase" (Latin *phasa*; abbreviation *—ph.*) suggested to me by Dr. G. A. K. Marshall is more appropriate, and its meaning will be made clear in the course of the explanation of my theory.

There is no doubt in my mind that *migratorioides* is the oldest form of the species, since its morphological and colour characters are far more constant in comparison with the more plastic *migratoria*, to say nothing of the extremely variable *danica*. The permanent breeding regions of *migratorioides* have never yet been investigated; the only description of breeding places of this form in the Malay States given by H. C. Pratt (*l.c.*, pp. 6-7) must obviously be referred not to the permanent breeding grounds, but merely to the places where the oviposition of emigrated swarms took place. All we know at present concerning the permanent breeding areas of *migratorioides* is based on the records of the occurrence of its swarms; and these data enable us to state that the best conditions for the development of this form seem to be present in tropical countries with a rather damp and hot climate, but undoubtedly not in forests. Since, on the other hand, these breeding grounds seem to be yet undiscovered, we may presume that they are also not in open, grassy land,

\* Die taxonomischen Grenzen der Art und ihrer Unterabteilungen. Berlin, 1910.

which is easily accessible and mostly cultivated or, anyhow, populated. I believe, therefore, that permanent breeding grounds of *migratorioides* are to be looked for somewhere deep in the impenetrable jungles, overgrown with high grasses, reeds, and such-like vegetation; but even if I am mistaken in this supposition, it would not affect my theory, which is based on the indubitable fact that the permanent breeding of *migratorioides* is possible only in localities with certain natural conditions, whatever those conditions may actually be.

Another well-known fact is that the development of *migratorioides* in its breeding grounds does not go on always at the same rate, but that it is subject to a periodical rise and fall, though the exact cause of the increase of locusts is entirely unknown. When the increase is at its height, large swarms are formed, and their emigration follows. Such emigrated swarms settle down and oviposit whenever they are compelled to do so by purely physiological causes, and their progeny undergoes a transformation into the solitary-living phase—*danica*. The very plastic, easily adaptable, and in all respects more progressive *danica* must play an important part in the extension of the range of the species, gradually but steadily populating new regions. Being a product of a mutation arising partly from some unknown internal cause and partly from outer (probably climatic) influences, *danica* is naturally subject to sudden displays of atavism, which results in the transformation into the ancestral phase *migratorioides*. We do not know yet whether this phenomenon can occur spontaneously as a result of some internal physiological factor, but there is no doubt that it is much favoured and often probably caused by the oviposition of *danica* taking place under conditions like those of the permanent breeding grounds of *migratorioides*. The gregariousness of the *migratorioides* phase is, of course, one of the causes of a rapid increase in the number of individuals and swarms, and soon—in the course of a few generations—the size of the swarms reaches the maximal point, which is followed by emigration. In this way the dispersion of the species goes on alternately by the gradual spreading of the *danica* phase and by the periodical extensive emigrations of *migratorioides*. As a result, the species is now distributed all over the Eastern hemisphere; but, as we know, the distribution of *migratorioides* is limited to tropical regions only, while *danica* goes over to the Palaearctic region as well, where the swarming phase of the species is represented by *migratoria*. This latter fact might be satisfactorily explained by the impossibility of finding in the Palaearctic region the natural conditions exactly like those of the tropical breeding grounds of *migratorioides*, chiefly in regard to a combination of heat and dampness. The above-described (p. 143) reed-beds of *Phragmites* in the south-eastern part of the Palaearctic region represent in all respects the nearest possible approach to tropical conditions. This statement is strongly supported by the fact that the fauna of these reed-beds includes two more Acridjans of an undoubtedly tropical origin; these are *Gelastorrhinus sagitta*, Uvar., and *Oxya turanica*, Uvar., both described\* from the valley of the Amu-Darya, in Transcaspia, and the former found also on the River Kura, in Transcaucasia. Though very peculiar, and in the summer recalling the tropics, the climatic conditions of these reed-beds are, of course, not tropical, and their effect on the progeny of *danica* breeding there is not the same as in the tropical breeding grounds of *migratorioides*: the reverse transformation of *danica* into a swarming phase does not reach the phase of *migratorioides*, but stops half-way at the *migratoria*-phase. This seems to indicate that the transformation is due primarily to the direct influence of external conditions, its extent being proportional to changes in the latter, but only precise laboratory investigations can help to clear up this complicated problem. It is interesting to recall here that individuals of *migratoria* incidentally occur in tropical countries also (see p. 152), and we may presume that their appearance is due to some abnormal conditions of the development.

\* *Horae Soc. Entom. Ross.*, xl, No. 3, 1912.

Little is known yet as to what happens in the breeding grounds after the emigration,\* except that the number of locusts drops suddenly to a minimum. I presume that scattered swarms of the gregarious phase, as well as the progeny of individuals of the solitary phase, cause the gradual increase in the number of swarming individuals, and after a few years a new emigration occurs.

Thus, the periodicity of locust invasions is caused entirely by the wonderful phenomenon of the transformation of a swarming locust into a solitary, harmless grasshopper. Of course, the outline here sketched is necessarily rough, and the actual proceedings are far more complicated, but the theory seems to me to be the best possible in the circumstances.

The biological result of these phenomena is that the maintenance and dispersion of the species is ensured in all circumstances: the swarming phases enable the species to extend at one stroke its area of distribution to distant regions, and its dispersion to the remotest islands is undoubtedly due to emigrating swarms; on the other hand, the well protected and easily adaptable solitary phase secures a strong footing in the countries thus reached, and under favourable conditions gives rise to new emigrants; the results achieved show that such an arrangement has been extremely useful to the species. Even the most radical changes in the natural conditions of the permanent breeding regions would result not in the extermination of the species, but only in its transformation into the more adaptable *danica* phase.

An example of that kind occurred in Southern Russia. Though the now existing permanent breeding regions are restricted, as I have described above (p. 143), to the valleys of the rivers discharging into the Caspian and Aral Seas and Lake Balkhash, the deltas of rivers emptying into the Black Sea (*i.e.*, Kuban, Don, Dnieper, Danube, etc.) also harboured not very long ago—up to the end of the eighties of the last century—some permanent breeding grounds of *migratoria*. At present, however, only the lower valley of the Danube is still a breeding region, while the valleys of the other rivers of the basin of the Black Sea no longer serve that purpose. This is easily explained by the fact that the valleys of the Don, Kuban and Dnieper were during the end of the last century more or less cultivated or, at any rate, their natural conditions were entirely changed by the persistent grazing of herds of cattle. As a direct result of this the possibility of the transformation of the solitary phase into the swarming one exists there no longer, and though the transformation takes place incidentally, single specimens of *migratoria* being not uncommon, their numbers do not increase, nor are swarms ever found.

The theory of phases suggests the theoretical possibility of the control of *migratoria* by some measures directed not against the insect itself, but against certain natural conditions existing in breeding regions which are the direct cause of the development of the swarming phase. The above-quoted example in South Russia shows that even comparatively slight cultivation of breeding regions leads to the desired changes; but the conditions necessary for the breeding of the swarming phase have not been exactly studied, nor are the direction and extent of such changes known. The first step, therefore, should be the most careful investigation of all existing, as well as extinct, breeding regions, together with parallel breeding experiments under laboratory conditions; on the basis of results thus gained a system of theoretically useful and practically possible measures for the conversion of breeding regions may be outlined.

#### IV. *LOCUSTANA PARDALINA*, WALK., AND ITS PHASES.

My personal knowledge of this locust is limited to the study of preserved specimens, especially of a large series sent to the Imperial Bureau of Entomology by Mr. J. C. Faure,

\* The direct cause of this ignorance is that injurious insects, and locusts especially, are studied only in the years of maximum development, and nobody cares about them in the minimum years, when the clue to the whole locust problem is most likely to be found.

of the Division of Entomology, Pretoria. Before proceeding to my own observations on the morphology of the species, I will quote an extract from a letter from Mr. Faure, dated 14th October 1920, which includes some very important and interesting information on the question of the phases of *L. pardalina*.

" My personal experience with the species began in the summer of 1914-15, when scattered swarms began to appear shortly after the break-up of a prolonged and very severe drought. Voetgangers (*i.e.*, nymphs) of all stages and flyers occurred together in loose swarms, and it was practically impossible to destroy them by the usual method of poisoning. The swarms did not move in the usual compact formation, nor did they camp for the night in dense clusters. Many of the adults were strikingly undersized, and a large percentage of both adults and voetgangers were abnormally coloured. Only in swarms that approached the normal in density did the typical orange and black colour of the voetgangers begin to show up.

" Although I did not realize the fact at the time, I was witnessing the transition from the grasshopper to the swarm phase. Towards the winter, that is in May and June 1915, the flyers began to move about in fairly definite loose swarms, and they laid their eggs in compact deposits, with the result that large swarms of typical swarm voetgangers hatched the following spring. We received no reports that winter of swarms of flyers coming into the Union from the Kalahari or anywhere else, and the outbreak in the period September to December 1915 was very severe in the area in which the scattered locusts had been observed the previous summer.

" It was quite evident, therefore, that the invasion of September-December 1915 had arisen from locusts bred up within the borders of the Union. Formerly the Kalahari Desert had been thought to be the chief source of our invasions of *Locusta pardalina*. Now we are convinced that large outbreaks can and do arise within our borders without the help of swarms coming in from the Kalahari. In the past, huge swarms have undoubtedly come into the Union from the Kalahari, and no doubt history may repeat itself in the future. But we no longer regard the Kalahari as a sort of permanent breeding ground, and are now inclined to believe that it will ordinarily only develop into a breeding ground if we allow swarms of flyers to escape into it from the Union.

" In 1917 I again saw scattered locusts from February to April, and another severe outbreak of voetgangers occurred the following spring and summer. In a general way it was a repetition of what had occurred in 1915, and realizing what was going on, I was better able to make observations.

" *Locusta pardalina* does not merely occur in scattered swarms and in compact swarms—it also lives as a grasshopper, *i.e.*, single specimens have often been collected miles away from the nearest swarm and in seasons when no swarms have been known to exist anywhere in the country. I have good reasons for believing that the species is probably never entirely absent from certain parts of the Union. During the past five years I have often searched for specimens during the intervals between the occurrence of swarms, and in practically every case I have succeeded in capturing two or three at least in say an hour's walk on the veld. Of course one should not expect to find them late in the winter or during a bad drought.

" The specimens captured singly almost always have the colours of the grasshopper phase, and they are as a rule a good deal smaller than swarm forms. Further, I have frequently taken last-stage nymphs and newly-fledged adults living the life of single grasshoppers. Although I have not been able to make a careful study of the specific characters of these single living forms, I am quite satisfied in my own mind that they are identical with the swarm forms. Again, these single forms may occur in the district or on the farm on which swarms are present, and I have on several occasions seen a few individuals with abnormal colours amongst a swarm

of typical swarm-form voetgangers. The only conclusion I could come to was that these stray forms have been picked up by the swarm. I have also found grasshopper-phase adults in a swarm of swarm-phase flyers, and have seen a very small green-marked male in copulation with a large typical female.

" These single forms of *L. pardalina* can readily be distinguished in the field from our other veld grasshoppers (1) by the fact that they have milky-white glistening underwings, and (2) by their peculiar manner of flight. They almost always soar upwards and then dip and swerve before settling down.

" From the swarm-phase the grasshopper-phase of *L. pardalina* differs chiefly in size and in colour. As regards colour, the single forms are remarkable for their great variability, and it would be quite an undertaking to describe in detail all the shades of colour they exhibit. Usually there is a striking protective resemblance. Where there is plenty of green grass both voetgangers and flyers may be almost entirely green, or at least partly green. Where the veld is only sparsely covered with grass and bushes, they resemble the colour of the soil more or less. In parts of the Karroo, notably Beaufort West and Prince Albert, there are patches of gravelly soil varying from slaty-blue to almost black. In 1917 I was greatly surprised to find a very striking tendency amongst the scattered voetgangers to vary in colour from place to place more or less in accordance with the colour of the soil. When the progeny of these scattered locusts appeared on the same farms in swarms six months later there was no trace of such a protective resemblance; they all wore the King's regulation swarm uniform!

" As far as size goes, the single-living forms are generally considerably smaller than the swarm forms. This is especially true of the males. Some of the males are so small that one can scarcely believe that they belong to the same species as the swarm males.

" When it occurs in large swarms *L. pardalina* scatters far and wide over the central plateau of South Africa, but its natural home is in the semi-arid parts of the country. It does not like the eastern Orange Free State, for instance, where there is a fairly good rainfall and a rather dense growth of grass. Its favourable breeding grounds are districts like those in the south-western corner of the Free State where the rainfall is slight and the veld consists of short grass mixed with short Karroo bush (*Pentzia*). In looking for scattered brown locusts I have got the habit of going to spots in the veld where there is an outcrop of white limestone in the red sand."

These valuable observations of Mr. Faure's leave no doubt that *L. pardalina* has, like *L. migratoria*, two different phases, which differ in morphology and coloration, but more profoundly in the biology. Especially striking is it that there is a sort of parallelism in the variation from the swarming to the solitary phase in both these species, as will be presently evident. My study of extensive series of both phases of *pardalina* sent by Mr. Faure, with a careful designation of the conditions under which each particular lot was collected (*i.e.*, whether from swarms or singly), enables me to state the following differences between them.

The difference in the shape of the pronotum is well marked, though less striking than that between *migratoria* (or *migratoriooides*) and *danica*. The pronotum of the swarming phase of *pardalina* (fig. 5, A & B) is more constricted before the middle, with the fore margin feebly prominent, the hind angle distinctly rounded, and the median keel slightly lower, and deeper cut by transverse sulci than in the solitary phase (fig. 5, D & E); but it is hardly possible to express these differences in figures, as I have done for the phases of *migratoria*, in which they are far more pronounced.

It is possible, however, to apply the method of proportions to another character—that of the relative lengths of the elytra and hind femora. As in *migratoria*, the elytra of the swarming phase of *pardalina* are relatively longer and the hind femora

shorter than in the solitary phase. The femoral proportion (*i.e.*, the length of hind femora expressed as a percentage of the length of the elytra) in the swarming phase averages 0.44, with a maximum of 0.47, and a minimum of 0.41; the average proportion for the solitary phase is 0.46, with 0.50 maximum and 0.41 minimum.

While the elytra of *migratoria* and *danica* do not differ except in the relative length, there exists a well-marked difference in the shape and venation of the elytra in the two phases of *pardalina*. Those of the swarming phase (fig. 5, C) are broader, with the fore margin more convex and the apex obliquely rounded, while the solitary phase (fig. 5, F) has the elytra narrower, with the margins almost straight and parallel and the apex obliquely truncate. The most striking difference, however, is in the venation: the discoidal field in the swarming phase is much broader, and its false vein distinctly curved and much thicker than in the solitary phase, in which this field is rather narrow, parallel-sided, and with the false vein only slightly thickened and almost, or even quite, straight. Naturally all these characters are subject to variation, and forms in all respects intermediate occur.

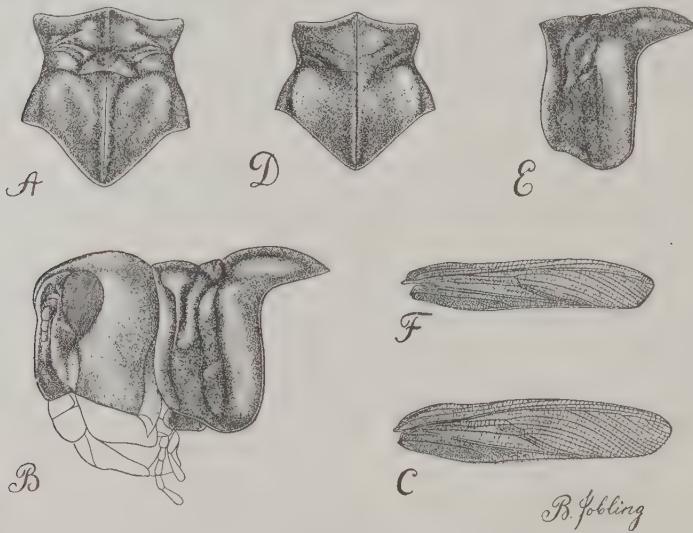


Fig. 5. *Locustana pardalina*, Walk.; A, B, C, phase *pardalina*; D, E, F, phase *solitaria*, Uvar., nov.; C and F, natural size, remainder  $\times 3$ .

The difference in the absolute dimensions between the two phases of *pardalina*, noted by Mr. Faure, is a phenomenon not observed in *migratoria*, but in the South African species it is well marked, the average length of the body of the swarming phase being 41 mm., while in the solitary phase it is only 34 mm., and occasional specimens occur even as small as but 24 mm. The individual variability in size is in the solitary phase very extensive, but the swarming phase is rather constant in this respect; this is also the case in the phases of *migratoria*. Again, sexual dimorphism is as well marked in the solitary phase of *pardalina* as it is in *danica*, the average length of the body being 32 mm. in the males and 36 mm. in the females, while the difference in the size of dwarf males, attaining about 22–24 mm., and the largest females with a length of nearly 45 mm. is very striking. The males of the swarming phase are scarcely smaller than the females, which agrees with the relative size of the sexes in typical *migratoria* or *migratoriooides*.

The extremely variable and decidedly protective general coloration of the solitary phase of *pardalina* in all stages of post-embryonic development, noted by Mr. Faure, exactly corresponds with the coloration of *danica*. The larvae of the swarming phase of *pardalina* present an astonishing likeness to those of *migratoria* and *migratorioides*, the coloration presenting the same combination of orange and black.\* The adults of the swarming form are rather uniformly coloured, and some bright yellow specimens in the series sent from Pretoria lead me to the suggestion that at the time of mating a general change of coloration may occur, as it does in *migratoria* (see p. 143). In the coloration of the most aberrant individuals of the solitary phase, one particular feature is noteworthy: the presence of a more or less pronounced pale or white oblique cross on the pronotum, which design is very characteristic of the species of the closely related genus *Oedaleus*.

An examination of the male genitalia revealed no difference whatever between the two phases of *pardalina*, but this was only to be anticipated.

The above-quoted conclusions of Mr. J. C. Faure concerning the transformation of the solitary phase into the swarming one, at which he arrived quite independently of my work on *migratoria*, give a very strong support to the theory of phases as a direct cause of the periodicity. His observations are especially interesting because they concern the period of the transition from the solitary to the swarming phase, on which my investigations of *migratoria* have given very few facts. It seems that in

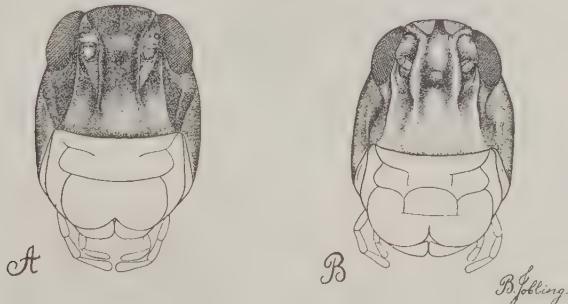


Fig. 6. Front view of head of: A, *Locusta migratoria* ph. *danica*, L.; B, *Locustana pardalina* ph. *pardalina*, Walk. ( $\times 4$ ).

*pardalina* the transformation of solitary individuals into the swarming phase takes more than one generation, but the actual causes of the transformation are in this case also obscure, as they are in *migratoria*. Data as to the migrations of the flyers and the fate of migrating swarms of *pardalina* are yet lacking, and further investigations of this problem, closely connected with the careful study of all conditions of breeding grounds, are extremely important from the point of view of locust control in South Africa.

## V. SYSTEMATIC PART.

### Key to the Genera *Locusta*, L., and *Locustana*, g. n.

1 (2) Frontal ridge not widened at the median ocellus (fig. 6, A). Pronotum (fig. 1, A, B, C, D, E) with the typical transverse furrow cutting the median keel about its middle; furrows in the prozona feeble. Mesosternal lobes only a

\* It is extremely interesting to note here that the larvae of most swarming and migratory locusts (*Schistocerca peregrina*, Ol., *Dociostaurus maroccanus*, Thb., etc.) present the same general type of coloration in black and reddish, or yellow, forming a very striking design. This phenomenon is well worth further investigation.

little longer than broad. Elytra (fig. 1, F) not less than five to six times as long as their maximal width; hind radial vein diverging from the middle radial only slightly and close to the bifurcation of the former; discoidal area much shorter than half the elytra; inter-ulnar area about half as broad again as the discoidal area, rather densely areolated, with areolets more than three deep, without a regular false vein. Hind femora narrow, more than four times as long as their maximal width; their upper margin more or less distinctly serrate; upper carina of the externo-median area straight. ♂: supra-anal plate (fig. 7, A) triangular, its surface practically flat; cerci (fig. 7, A) short, rounded, conical; subgenital plate with apex obtusely conical; penis (fig. 7, B) very large, strongly recurved apically. ♀ (fig. 7, E): subgenital plate with lateral margins straight; apex truncate; lower valves of ovipositor with basal part distinctly longer than broad, with an obtuse lateral tooth in the apical part . . . . . *Locusta*, L.

Genotype: *Gryllus Locusta migratoria*, L.

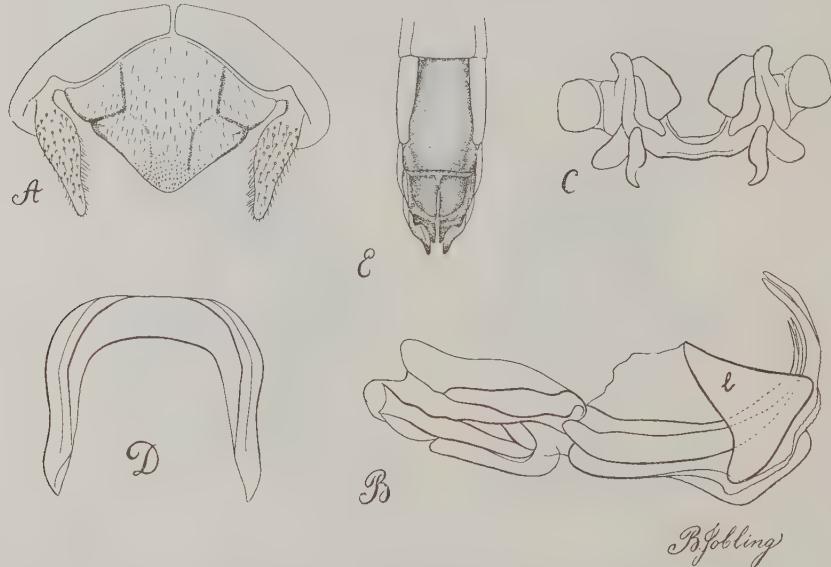


Fig. 7. Genitalia of *Locusta migratoria*, L.: A, male supra-anal plate and cerci from above; B, penis and lower genital valves (e) in profile; C, epiphallus; D, upper bridge of genital valves; E, end of female abdomen from beneath. (E  $\times$  3, remainder  $\times$  12).

2 (1) Frontal ridge distinctly widened at the median ocellus (fig. 6, B). Pronotum (fig. 5, A, B, D, E), with the typical transverse furrow cutting the median keel distinctly before the middle; furrows in the prozona deep. Mesosternal lobes distinctly longer than broad. Elytra (fig. 5, C, F) not more than four to five times as long as broad; hind radial vein strongly diverging from the middle radial long before its bifurcation; discoidal area almost as long as half the elytra; inter-ulnar area about as broad as the discoidal, sparsely areolated with two rows of areolets, separated by a false vein. Hind femora broad, less than four times as long as their maximal width; their upper margin not serrate; upper carina of the externo-median area convex. ♂: supra-anal plate (fig. 8, A) trapezoidal, with the apex prominent in the middle, irregularly denticulate, its surface with chitinous tubercles;

cerci (fig. 8, A) rather large, compressed laterally; subgenital plate with the apex slightly widened; penis (fig. 8, B) very short, with short acute apex. ♀ (fig. 8, E): subgenital plate with lateral margins slightly convex; apex rounded, with a median projection and bisinuate laterally; lower valves of ovipositor with the basal part about as long as broad, the apical part unarmed laterally . . . . . *Locustana*, g. n.

Genotype: *Pachytulus pardalinus*, Walk.

This key shows only the most striking differences between the two genera; other distinctive characters, especially those observed in the male genitalia, may be easily understood by a comparison of the figures (figs. 7 and 8).

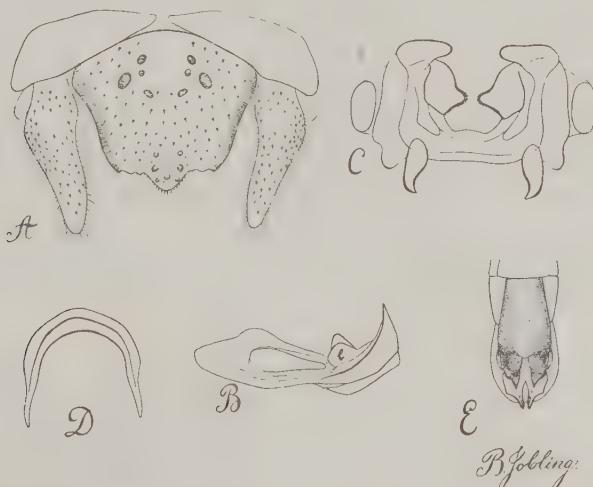


Fig. 8. Genitalia of *Locustana pardalina*, Walk. : A, male supra-anal plate and cerci from above; B, penis and lower genital valves (e) in profile; C, epiphallus; D, upper bridge of genital valves; E, end of female abdomen from beneath. (E  $\times 3$ , remainder  $\times 12$ ).

A full description of the new genus *Locustana* is given below.

*Key to the Phases of Locusta migratoria, L.\* (figs. 1 & 4).*

- 1 (2) Pronotum distinctly compressed laterally, but feebly constricted before the middle; median keel high, tectiform, convex in profile; the fore margin angulately prominent; the hind angle acute. Hind femora (on the average) longer than half the elytra. Hind tibiae often red. Larvae of variable coloration, but never black and red (or black and yellow). Both larvae and adults occur singly or in very loose swarms . . . . ph. *danica*, L.
- 2 (1) Pronotum only feebly compressed laterally, but distinctly constricted before the middle; median keel low, neither tectiform, nor convex in profile; fore margin not prominent; hind angle not acute. Hind femora (on the average) shorter than half the elytra. Hind tibiae only exceptionally red. Larvae of a constant black and red (or black and yellow) coloration. Both larvae and adults occur in dense swarms.

\* It is quite obvious that the exact determination of the phases is possible only in the case of typical specimens and not of intermediate examples; the most reliable results can be obtained only from examination of large series.

3 (4) Pronotum with the median keel straight in profile; hind margin rotundato-  
angulate ... ... ... ... ph. *migratoria*, L.  
4 (3) Pronotum with the median keel concave in profile; hind margin widely  
rounded ... ... ... ... ph. *migratorioides*, Rch. & Frm.

### Synonymic Notes.

The synonymy of *L. migratoria* ph. *migratoria*, L., and *L. migratoria* ph. *danica*, L., is quite correctly given by W. F. Kirby in his Catalogue (iii, pp. 229, 230), apart from the fact that he distinguishes them as two different species, and I think it unnecessary to repeat it here. To the synonyms of *danica*, however, must be added *Pachytylus australis*, Sauss. (Prodr. Oedip., pp. 119, 120, no. 5, 1884), but not *Locusta australis*, Froggatt (Agric. Gaz., N.S. Wales, xiv, p. 110, 1903), which represents *Gastrimargus musicus*, F., as has already been stated by Prof. Y. Sjöstedt (Ark. Zool., xii, no. 20, p. 11, 1920).

*Pachytylus capito*, Sauss. (Prodr. Oedip., pp. 119, 120, no. 4, 1884) is undoubtedly identical with *L. migratoria* ph. *migratorioides* (Rch. & Frm.).

*Pachytylus minor*, Sauss. (Abh. Senck. Naturf. Ges., xxi, p. 631, 1899) belongs to the genus *Pternoscirta*, as I am able to state from an examination of good photographs of the type specimen most obligingly taken for me by Dr. J. Carl, of the Geneva Museum.

The only remaining species of *Locusta* in Kirby's Catalogue is *L. pardalina* Walk., conspecific with *sulcicollis*, Stål, and *capensis*, Sauss., which is here made the type of the new genus *Locustana*, m.

### A Description of the Genus *Locustana*, nov. (figs. 5, 6 B & 8).

Antennae distinctly compressed dorso-ventrally. Frontal ridge in profile straight or feebly concave, distinctly widened and impressed around the median ocellus, flat elsewhere, with the margins very obtuse, disappearing just below the ocellus. Fastigium of the vertex slightly sloping, forming a straight widely rounded angle with the frontal ridge, flat, distinctly longer than broad, with the margins distinctly raised, convex, with the median keel always developed; the distance between the eyes slightly less than twice as broad as the frontal ridge between the bases of the antennae. Eyes oval, with the fore margin almost straight; their width in the broadest part, which is in the middle, is equal to about half their maximal height. Pronotum with the prozona constricted, deeply furrowed, convex between the furrows; the typical furrow cuts the median keel distinctly behind the middle; median keel moderately elevated; lateral lobes with the hind angle widely rounded. Mesosternal lobes distinctly broader than long, their inner angles widely rounded; mesosternal interspace subquadrate in the female and slightly longer than broad in the male. Elytra hyaline throughout, except the basal parts of the marginal and basal areas, which are coriaceous; rather broad and short, not more than four to five times as long as their maximal width; apex oblique; hind radial vein strongly diverging from the middle radial long before its bifurcation (halfway between the base and the bifurcation); discoidal area almost as long as half the elytra, with a sinuate or straight false vein; inter-ulnar area about as broad as the discoidal, or scarcely broader, sparsely areolated, with two rows of the areolets separated by a rather regular false vein; axillar vein free, in most cases reaching the hind margin. Wings rather short, not more than twice as long as their greatest width. Hind femora rather broad—less than four times as long as their maximal width; upper keel not serrate; upper carina of the externo-median area distinctly convex.

♂.—Supra-anal plate, with strongly chitinized margins, trapezoidal, distinctly longer than the basal width; its surface distinctly concave, with several small chitinous tubercles in the basal half, forming a trapezium; outer margins nearly straight;

apex triangularly prominent, irregularly denticulate; hind angles obtusely rounded. Cerci rather large, strongly compressed laterally. Subgenital plate subconical, with the apex attenuate and slightly widened. Penis\* short, widely and obliquely truncate posteriorly, with the apex triangular, sharp; upper genital valves large, united with the penis; lower valves small, lying close to the sides of the penis and covering about half of it laterally, with obtuse upper projections; they are connected with each other above the penis by a bow-shaped transverse bridge emitting forwards two long, apically narrowed, lateral branches; epiphallus large, with the two upper apophyses obtusely rounded and projecting inwardly and with lower sharply pointed, beak-shaped teeth, with the inner lobes rounded and minutely and obtusely serrate near the lower angles.

♀.—Supra-anal plate obtusely triangular. Subgenital plate much longer than broad, widened posteriorly, with the lateral margins slightly convex; apex rounded, bisinuate, with a small projection in the middle. Upper valves of the ovipositor with short, strongly recurved, rather obtuse apices and not very sharp margins. Lower valves with the basal part about as long as broad; apical part without lateral teeth, with widely rounded lateral angles; apices feebly decurved, short, acute.

Genotype: *Pachytalus pardalinus*, Walk.

*Key to the Phases of Locustana pardalina, Walk.*† (fig. 5).

1 (2) The average size smaller; the males much smaller than the females. Pronotum more compressed laterally between the shoulders, but less constricted before the middle; median keel more raised, not lower in prozona than in metazona; fore margin more or less projecting in the middle; hind angle sharp. Elytra shorter and narrower, with the margins almost straight and parallel, with the apex obliquely truncate; discoidal area narrower, parallel-sided, with the false vein straight and not incrassate. Coloration of larvae, as well as that of the adults, very variable, but the larvae are never coloured black and red. Both larvae and adults occur singly and in loose swarms. . . . . ph. *solitaria*, n. ph.

2 (1) The average size larger; the males only a little smaller than females. Pronotum not compressed laterally between the shoulders, but strongly constricted before the middle; median keel less raised, in prozona distinctly lower than in the metazona; fore margin straight; hind angle rounded. Elytra broader and also longer, with the margins convex, and the apex obliquely rounded; discoidal area broader, with the sides sinuate, and the false vein distinctly incrassate and sinuate. Coloration of the larvae uniformly black and red. Both larvae and adults occur in dense swarms ph. *pardalina*, Walk.

\* The terminology of the parts of the genitalia adopted here is that of L. Chopard (Recherches sur la conformation et le développement des derniers segments abdominaux chez les Orthoptères.—Thèses présentées à la Faculté de Sciences de Paris; Série A, No. 847, 1920).

† See the footnote on page 161.



ON NEW SPECIES OF CURCULIONIDAE ATTACKING FOREST TREES  
IN INDIA.

By GUY A. K. MARSHALL, C.M.G., D.Sc.

Subfamily BRACHYDERINAE.

**Sympiezomias beesoni**, sp. nov. (fig. 1).

♂♀.—Black; the head and rostrum with thin blue-grey scales; the prothorax with rather sparse dull blue scales on the dorsum, the sides entirely clothed with dense metallic green scales; the disk of the elytra as far as stria 4 covered mainly with blackish scaling, more or less interspersed with green scales, which are sometimes denser along the suture; beyond stria 4 the sides are clothed with dense pale green scaling almost to the margin, the inner edge of the green area being very irregular; the lower surface with dense greyish green scaling.

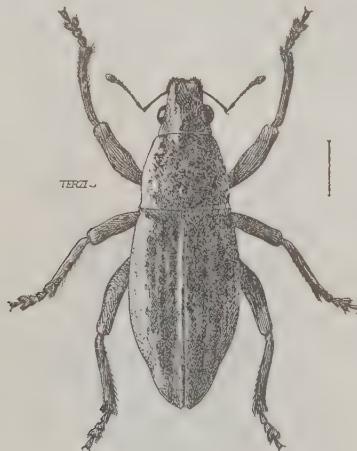


Fig. 1. *Sympiezomias beesoni*, sp. n.

*Head* with coarse punctuation that is usually confluent longitudinally, and often with a very faint broad transverse impression behind the eyes; the vertex rarely with a median stria, but usually with a central fovea. *Rostrum* a little longer than its basal width, shallowly impressed in the middle, with the usual short median furrow, which is not continued on to the forehead, the carinae on each side well marked and parallel. *Antennae* piceous; joint 1 of the funicle slightly longer than 2. *Prothorax* a little broader than long, narrower in front than behind, broadest about the middle, the sides gently rounded; with coarse confluent punctuation above, the interspaces

finely and sparsely punctate, without any dorsal stria or impressions; the setae very short, flattened and recumbent. *Elytra* narrowly ovate in ♂, only slightly broader in ♀, with the basal margin strongly raised and the humeral fold not very prominent, the apices not mucronate in either sex; the striae strongly punctate, the intervals slightly convex and of even height, except that interval 1 is somewhat raised at the apex; the flattened setae short, recumbent and inconspicuous on the basal half, longer and more curved behind. *Legs* with the hind tibiae not denticulate internally.

*Length, 7-8.75 mm. ; breadth, 2.75-3.5 mm.*

MADRAS: S. Malabar, Nilambur, 5 ♂♂, 14 ♀♀, vii.1918 (C. F. C. Beeson); S. Malabar, Nadengayam, 2 ♂♂, 1 ♀, xi.-xii.1917 (N. C. Chatterjee).

Owing to its green scaling and non-mucronate elytra this species comes nearest to *S. frater*, Mshl., which, however, has the whole upper surface with uniform green scaling; the latter also differs in having no median impression on the rostrum, the eyes are less convex, the pronotum is much more finely sculptured, and the intervals on the elytra are flatter.

These weevils were found feeding on the leaves of young teak, and in some cases defoliating the trees.

#### Subfamily ALCIDINAE.

##### ***Alcides dipterocarpi*, sp. nov. (fig. 2).**

♂ ♀.—Colour red-brown, the head, rostrum, prothorax and the humeral angles of the elytra blackish; the elytra very sparsely set with small narrow pale scales, and without any squamose markings.



Fig. 2. *Alcides dipterocarpi*, sp. n.

*Head* coarsely and confluent punctate, with a shallow furrow just above each eye, and the forehead broadly but shallowly impressed. *Rostrum* as long as (♂) or a little longer than (♀) the front femur, parallel-sided from the base to the middle, then narrowing slightly and widening again to the apex, which is a little broader than the base; coarsely and closely punctate throughout, the punctures on the apical

half scarcely smaller than those at the base, with a shallow elongate median fovea above the insertion of the antennae, and with a smooth median line on the apical half only; the sides clothed in the basal half with spatulate scales that are fringed at the apex; ♂ without any projection on the submentum. *Antennae* with joint 1 of the funicle about as long as the next three together, 4-6 subequal and as long as broad, 7 densely squamose and a little longer than its apical width. *Prothorax* nearly twice as broad as long, broadest at the base, the sides gently rounded and markedly constricted near the apex, the dorsum closely set with low convex granules, except the apical area, which is strongly punctate; each granule bearing a forwardly-directed seta (usually bifid) on its anterior edge, and the sides of the apical area with numerous fan-shaped plumose scales, a few of which occur also on the median basal lobe. *Scutellum* small, transverse, tilted forwards, and not at all enclosed in front by the elytra. *Elytra* broadly heart-shaped, scarcely longer than the width at the shoulders, which are obtusely prominent; the striae containing round, deep punctures, which are for the most part separated by more than their own width and become much shallower behind; the intervals broader than the striae, convex, transversely rugose, but not granulate, and sparsely set with small setiform scales, which are often bifid, trifid or quadrifid. *Legs* comparatively short and stout, and thinly clothed with narrow, cleft scales; the hind legs unusually short, so that when outstretched the femur reaches only the apex of ventrite 6 (4th visible), and the tibia exceeds the elytra only by its apical third; the tooth on the front femora of very unusual shape (fig. 3), being in the form of an irregularly trifid

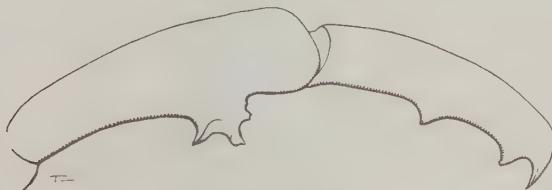


Fig. 3. Front femur and tibia of *Alcides dipterocarpi*, sp. n.

lamina, that on the mid-femora truncate at its apex and with two minute teeth on its external edge, that on the hind femora very small and simple; the front tibiae with a stout median tooth on the inner edge and a subapical one of almost equal size, the mid-tibiae with a subapical tooth but no median one, and the hind tibiae simple. *Venter* clothed with cleft scales, which only partly conceal the integument; ventrite 7 (last visible) with a large rounded median impression in the ♂.

*Length*, 6.5-7.2 mm.; *breadth*, 4.25-4.8 mm.

UNITED PROVINCES: Dehra Dun, bred from seeds of *Dipterocarpus*, vii.1911.

Described from four specimens.

The rhomboidal outline and general structure make this species look like a very small *A. crassus*, Pasc., from the Andamans; but the latter differs, *inter alia*, in having a median internal tooth on all the tibiae, the intervals on the elytra are quite smooth and sparsely punctate, the tooth on the fore femora is triangular with a denticulate outer edge, and the ♂ has two tufts of setae on ventrite 7.

There are several closely allied, and apparently undescribed, species in Malaya, from all of which *A. dipterocarpi* may be distinguished by the peculiar form of the tooth on the front femora (fig. 3).

*A. morio*, Heller, from South India, is also of very similar appearance, but the elytra are much less narrowed behind, the front coxae are closely approximate, and all the tibiae lack the median tooth and the subapical one is inconspicuous.

Subfamily CRYPTORRHYNCHINAE.

**Mecistocerus fumosus**, sp. nov. (fig. 4).

♂ ♀.—Colour black, with dense blackish or very dark sooty brown scaling above, sometimes sparsely variegated with lighter brown scales; the lower surface with dense sandy brown scaling, the venter with a very broad, median, dark brown stripe throughout.

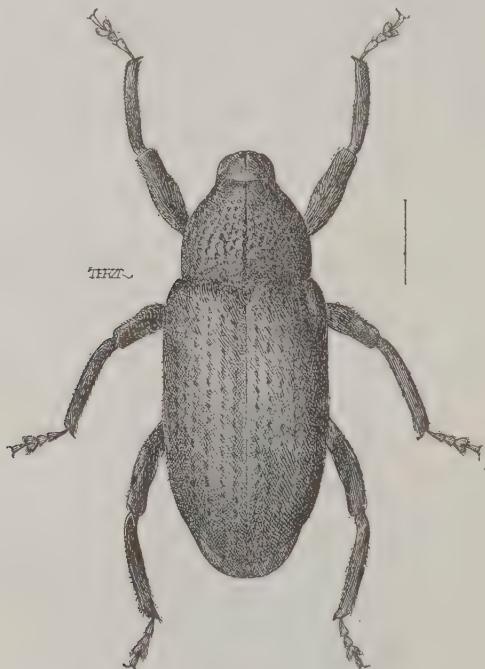


Fig. 4. *Mecistocerus fumosus*, sp. n.

*Head* with the vertex bare and with coarsely reticulate punctures; the anterior part densely clothed with curled scales, completely hiding the integument, which is much more finely sculptured than the vertex, bearing shallow larger punctures interspersed with much smaller ones; the frontal fovea very deep and elongate, the scales between it and the eye mostly erect. *Rostrum* of ♂ blackish in the basal half and red-brown towards the apex, coarsely punctate towards the base and there tricarinate dorsally, the apical part finely and sparsely punctate, the antennae inserted at the middle; of ♀, paler, a little longer and more slender, more finely punctate throughout, and with the antennae inserted behind the middle. *Antennae*

red-brown, the funicle sparsely clothed with recumbent pubescence, the joints clavate, the two basal ones equal, the remainder slightly and progressively diminishing in length, all of them being longer than broad, except 7, which is about as broad as long; the club subcompressed, markedly broader than the funicle, as long as the three preceding joints together, the first joint of the club as long as the remainder. *Prothorax* with the sides subparallel from the base to the middle, thence roundly narrowed to the apex and without any apical constriction; the dorsum flattened, with the usual very large and deep reticulate punctures, diminishing in size and depth anteriorly, the interspaces shiny, not setose, and with squamiferous punctures, without any real carina, but with a median undulating impunctate line that nearly reaches the base and apex; the scaling on the disk rather thin and recumbent, the scales on the sides larger, denser and slightly raised, and a sharply defined line on the pleura between the dark dorsal and pale ventral scaling. *Scutellum* trapezoidal, broadest behind, about as long as its apical width, markedly flattened and sparsely punctate. *Elytra* unusually flattened, the shoulders prominent; the posterior callus distinct but obtuse; the intervals plane, not elevated or granulate at the base, a little broader than the large deep punctures, which are partly hidden by the dense scaling; when abraded the transverse septa between the punctures are seen to be raised a little higher than the intervals between the rows; the scales very dense, suberect, and with the tips curved downwards, the scale-like setae so short in the male as to be hardly distinguishable from the scaling, a little longer and obliquely raised in the ♀. *Legs* with blackish scaling, except on the basal half of the femora, where it is light brown; the upper apical angle of the hind tibiae prominent, forming a sharp right angle. *Venter* densely squamose at the sides, more thinly so in the middle, with scattered raised squamiform setae; ventrites 3, 4 and 7 (nominally 1, 2 and 5) with numerous large deep punctures, the interspaces with fine scattered punctures, ventrites 5 and 6 each with a single transverse row of larger shallow punctures.

*Genitalia\** of ♂ (fig. 5) with the median lobe almost parallel-sided, with a very

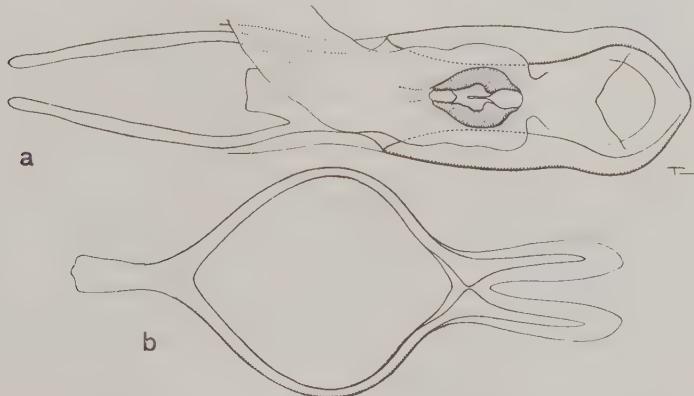


Fig. 5. Genitalia of *Mecistocerus fumosus*, sp. n., ♂ *a*, aedeagus; *b*, tegmen.

slight lateral sinuation near the apical third and the apex broadly rounded, only the entire margin being heavily chitinised (probably immature); the uneveted sac

\* The terms used are those suggested by Dr. D. Sharp, F.R.S. (Trans. Ent. Soc. Lond. 1918, pp. 209-222.

containing a pair of large lunate chitinous plates about the middle, the surface of the sac around them being closely studded with asperities, and no plates at the median orifice ; the tegmen with the ring not closed in the normal manner, but the chitinous rim continued vaguely into the corresponding dorsal lobe on each side, the lobes united for a short distance at the base and a little shorter than the length of the ring, the strut being only half this length. *Genitalia* of ♀ with a rather irregular, oblong chitinous patch in the wall of the vagina opposite its junction with the oviduct, and a similar broad V-shaped plate adjoining it anteriorly ; the spermatheca (fig. 7, d) very broadly comma-shaped, the apex obtusely rounded, and the accessory gland twice as long.

*Length*, 5·4-11 mm. ; *breadth*, 2·2-4·8 mm.

UNITED PROVINCES : W. Almora div., Kumaon, on *Pinus longifolia* (H. G. Champion—type) ; Ranikhet, Kumaon, bred from *P. longifolia* (H. G. C.). PUNJAB : Dalhousie Range, Chamba State, bred from *P. longifolia* (C. F. C. Beeson).

Its remarkable dark sooty colouring and flattened upper surface distinguish this species from all its Indian congeners.

The species of this genus possess a stridulatory apparatus, which is the same in the two sexes, and consists of a file formed of transverse striae at the apex of each elytron on the lower surface ; the scrapers that play on these files are situated on the seventh abdominal tergite and consist of two longitudinal rows of small, rather widely spaced granules.

#### Genus **Rhadinomerus**, Fst.\*

In his revision of the African species of *Mecistocerus* and *Rhadinomerus* (Ent. Tidsk. xxv, 1904, p. 186) Prof. K. Heller treats the latter genus as merely a sub-generic division of *Mecistocerus*. I agree with him that the supposed differences in the structure of the venter used by Faust are quite unreliable ; but this does not apply to the form of the femora. In *Mecistocerus* these organs are clavate, being markedly narrowed towards the base, whereas in *Rhadinomerus* they are sublinear, being but little or not at all narrowed at the base ; moreover, as Faust indicated later (Ann. Mus. Civ. Genova, xxiv, 1894, p. 279, note), the species of *Mecistocerus* can be distinguished by the presence of an elongate bare shiny patch at the base of the femora on the dorsal edge. But a more important point, which has hitherto been overlooked, is that *Rhadinomerus* entirely lacks the apical stridulatory apparatus that is present in both sexes of *Mecistocerus* ; and, finally, in females of the latter genus the eighth abdominal tergite is as long as or longer than broad, whereas in *Rhadinomerus* it is distinctly transverse. On these grounds it seems desirable that Faust's genus should be retained unless these characters are shown to be unstable.

#### **Rhadinomerus bombacis**, sp. nov. (fig. 6).

♂♀.—Colour black ; the prothorax with sparse, large, pale scales, which often form a narrow median line and an indefinite lateral one on each side ; the elytra with very dense brown scaling, variegated with a few pale spots and transverse blackish

\* Faust, Stett. Ent. Zeit. 1892, p. 215.

patches ; the lower surface with a few sparse pale scales, especially towards the sides, and obliquely raised flattened setae down the middle.



Fig. 6. *Rhadinomerus bombacis*, sp. n.

*Head* coarsely reticulate on the vertex, the forehead with dense recumbent scales, which are larger behind than in front and partly conceal the median furrow, which is rather shorter and shallower than usual. *Rostrum* with the usual four coarsely punctate furrows and three narrow carinae at the base ; the antennae inserted a little in front of the middle in ♂ and a little behind it in ♀. *Antennae* with the funicle clothed with dense, erect pubescence ; the comparative lengths of the funicular joints, beginning with the longest, are as follows : (1, 2) (3, 4) (5, 6) 7, all being longer than broad except 7, which is as broad as long or slightly transverse ; the club only slightly broader than the funicle, its first joint not longer than the second. *Prothorax* a little broader than long, with the sides very gently rounded, broadest about the middle, very slightly narrowed behind and much more so in front, with a shallow constriction near the apex ; the dorsum, except the apical area, set with very large, deep, reticulate punctures, and sometimes with a trace of a much abbreviated median ridge ; the punctures on the pleurae smaller and much shallower and with the intervals duller and more punctate ; the pale scales much larger than those on the elytra, oblong, convex and veined ; at the base of each puncture a suberect dark spatulate seta directed forwards. *Scutellum* small, rounded, very convex and prominent. *Elytra* subcordate, much broader than the prothorax at the shoulders, which are roundly rectangular, with the sides subparallel from the shoulders to the middle and rather abruptly narrowed behind, being markedly constricted at some distance before the apex ; the large deep subquadrate punctures becoming much shallower behind ; the slightly convex intervals as broad as the punctures and a little higher than the septa between them, with indistinct granules, which are more evident near the base, where the intervals are rather higher, each granule bearing a slightly raised short scale-like seta. *Legs* with dense, light brown scaling ; all the femora with a faint, pale dorsal patch beyond the middle, behind which on the posterior pairs is a large dark patch ; the tibiae with the basal half darker, except for a pale dorsal

spot at the extreme base. *Abdomen* with coarse deep punctures on ventrites 3, 4 and 7 (nominally 1, 2 and 5), the punctures on the two former being denser on the disk than at the sides; ventrites 5 and 6 impunctate and with the anterior edge crenulated.

*Genitalia* of ♂: the median lobe (fig. 10, c) oblong, troughlike and very slightly narrowed towards the base, only lightly chitinised, except the inflexed lateral margins and a transverse strip close to the apex, the latter area being dispersely punctate, the apex broadly rounded, the base forming a sharp right angle on each side, and the median orifice membranous and inconspicuous; the median struts slender, two-thirds longer than the lobe, with a strong double sinuation in the basal third, and connected together for a short distance at the base by an indefinite extension of the lightly chitinised floor of the lobe; the unevected sac extending between the struts to the end of the sinuated part, containing a small, median, lanceolate, chitinised patch in the lobe close to its base, and the transfer-apparatus at the extremity of the sac composed of two short juxtaposed hairpin-shaped pieces; the tegmen (fig. 11, c) with the strut a little shorter than the ring, and this again shorter than the lobes, which are fused together for a very short distance at the base; the spiculum twice as thick as the median struts and slightly dilated at the apex, the basal fork forming a very wide angle, one branch being twice as long as the other and abruptly curved at its apical third. *Genitalia* of ♀: spermatheca as shown (fig. 7, a).

Length, 3.8-6.5 mm.; breadth, 1.8-3.5 mm.

UNITED PROVINCES: Pathri, Sarahanpur, bred from logs of *Bombax malabarica*, xii.1917-iv.1918 (C. F. C. Beeson).

BIHAR & ORISSA: Singhbhum, from *Bombax malabarica*, i.1921 (Beeson).

Described from 24 specimens.

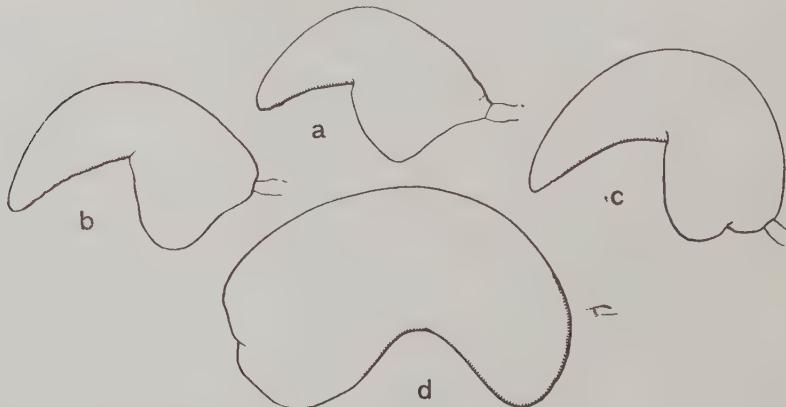


Fig. 7. Spermatheca of (a) *Rhadinomerus bombacis*, sp. n.; (b) *R. subfasciatus*, sp. n.; (c) *R. malloti*, sp. n.; (d) *Mecistocerus fumosus*, sp. n.

**Rhadinomerus diversipes**, sp. nov. (fig. 8).

♂ ♀.—Head and prothorax blackish brown; elytra, venter and legs red-brown; the prothorax with the apical area densely clothed with pale brown scales and

a few similar scales scattered over the disk, and with short, erect, dark setae; the elytra rather thinly clothed with uniform pale brown scales (sometimes variegated with paler spots), and with obliquely raised pale squamiform setae; the sternum with sparse, pale, fine erect setae, the venter with a very few pale scales and with flattened, erect, pale setae.

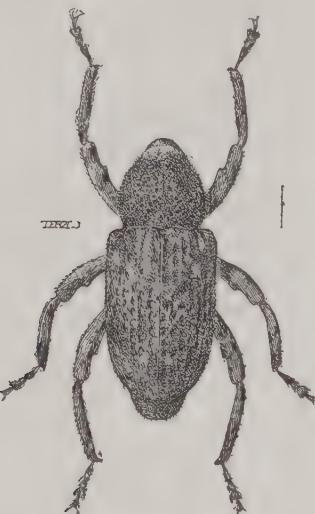


Fig. 8. *Rhadinomerus diversipes*, sp. n.

**Head** bare and coarsely but shallowly reticulate on the vertex; the forehead on a slightly lower plane, with much shallower and smaller punctures, and with dense pale scales; the frontal furrow very broad and deep. **Rostrum** tricarinate at the base, as usual, with a small patch of raised pale scales in the middle of the base and some erect, pale, squamiform setae; the antennal insertion at (♀) or beyond (♂) the middle. **Antennae** testaceous, with the apical half of the funicle clothed with sparse, recumbent pubescence; the funicular joints in order of diminishing length: (1, 2), 3, 4, 5, (6, 7); 5 as long as broad, 6 and 7 slightly transverse, the rest longer than broad; the club with the basal joint a little shorter than the rest together. **Prothorax** a little broader than long (11:9), with the sides rounded, broadest at the middle, slightly narrowed to the base and shallowly constricted at the apex; the reticulate punctures not very large, but deep; the interspaces dull, finely coriaceous, and sloping inwards towards the puncture, each bearing a single erect, compressed, dark seta; the median carina reduced to a very short sinuous line in the middle, and sometimes almost obliterated. **Scutellum** almost circular, strongly convex, shiny, and with a few short recumbent hairs. **Elytra** subcylindrical, shallowly constricted close to the apex and with an obtuse posterior callus; the oblong punctures deep and diminishing behind, each covered by an oblong horizontal scale attached to the front margin, and on each side a small blackish prominence within the puncture; the intervals about as broad as the punctures, somewhat raised and rugulose close to the base, but almost smooth elsewhere; the scales varying from oval to oblong, not sufficiently dense as to conceal the entire integument, and shorter than those on the apical area of the prothorax; the setae compressed, obliquely raised, and in widely spaced rows. **Legs** with not very dense, uniformly pale brown scales; the

apex of the hind tibiae of the ♂ alone produced inwardly almost at right angles to the tibia in the form of a lamina (fig. 9), having at its apex two short teeth representing



Fig. 9. Hind tibia of *Rhadinomerus diversipes*, sp. n. ♂.

the uncus and mucro, the former being the longer. *Abdomen* with very large separated punctures on ventrite 3 (1st visible), the punctures being at most two deep on the shortest portions (behind the coxae); ventrites 4-6 with only a few much smaller punctures close to the lateral margins; ventrite 7 coarsely and closely punctate; 5-7 with the anterior edge very broadly emarginate and bearing a close fringe of short hairs, the emargination forming a well-marked obtuse angle at each end.

*Genitalia of ♂*: the median lobe (fig. 10, a) oblong, parallel-sided, and moderately

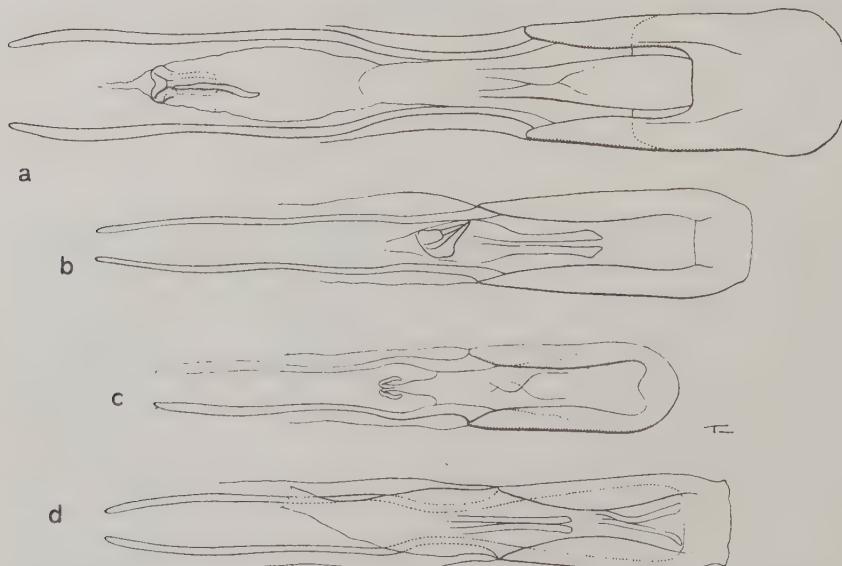


Fig. 10. Male genitalia (median lobe) of (a) *Rhadinomerus diversipes*, sp. n.; (b) *R. malloti*, sp. n.; (c) *R. bombacis*, sp. n.; (d) *R. subfasciatus*, sp. n.

chitinised throughout, except for an apical hyaline area which is broadly truncate, the base sharply angulate on each side, the median orifice at about the middle of the lobe, and the apical half with a few sparse punctures; the median struts slender, gently sinuous throughout, and half as long again as the lobe, with which they do not definitely unite but merge gradually into the lateral edges of an abruptly narrowed,

indefinite, basal chitinous extension of the floor of the lobe; the uneveted sac extending between the struts for three-fourths of their length, its terminal third covered with asperities, the transfer-apparatus conspicuous and in the form of two juxtaposed crook walking-sticks with the crooks turned outwards; the tegmen (fig. 11, a) with the proportionate lengths of the strut, ring and dorsal lobes as 4:2.5:5, the lobes being fused together for one-third of their length from the base; the spiculum as broad as the tegminal strut, widely dilated at the apex, and the basal fork forming a right angle with the branches nearly equal in length.

Length, 3.5-2 mm.; breadth, 1.4-2.4 mm.

UNITED PROVINCES: Lachiwala, Dehra Dun, bred from *Eugenia jaman*, x.1914 (C. F. C. Beeson—type), and from *Shorea robusta*, xi.1915 (Beeson); Surajbagh, Dehra Dun, bred from *Eugenia jaman*, xi.1915 (Beeson); Jubberkhet, Dehra Dun, bred from *Shorea*, xii.1915-i.1916 (Beeson).

Described from 8 specimens.

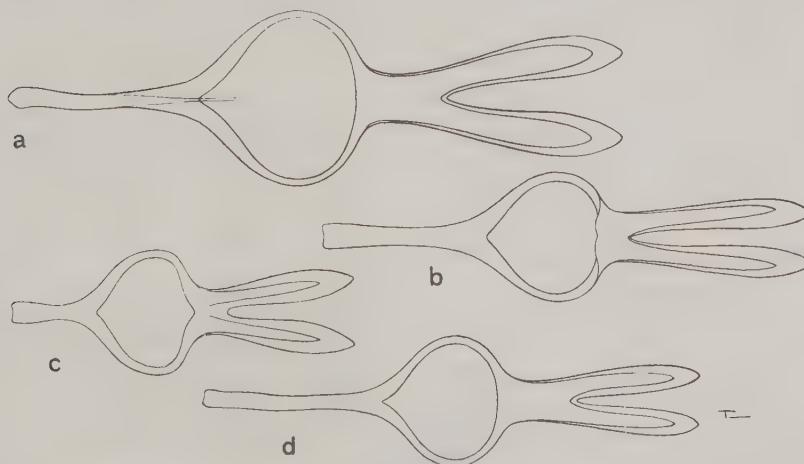


Fig. 11. Male genitalia (tegmen) of (a) *Rhadinomerus diversipes*, sp. n.; (b) *R. malloti*, sp. n.; (c) *R. bombacis*, sp. n.; (d) *R. subfasciatus*, sp. n.

#### **Rhadinomerus malloti, sp. nov.**

♂ ♀.—Head and prothorax blackish, the latter with yellowish brown scales on the apical area only; the elytra piceous, irregularly mottled with lighter and darker brown scaling; the lower surface without true scales, but sparsely set with short and comparatively fine setae.

Extremely similar to *R. diversipes*, but distinctly broader in proportion to its length. In that species the intervals between most of the punctures on the prothorax are flattened and tilted inwards towards the puncture, so that the ridge is on the outer or posterior edge; in *R. malloti* these intervals are normally convex with the ridge approximately in the middle. The scales in *R. diversipes* are oblong, with the apex truncate or broadly rounded; in *R. malloti* they are narrowly ovate or lanceolate, with the apex pointed, and the setae are distinctly narrower. In the present species ventrite 3 (1st visible) is more closely punctate, the punctures being three deep behind the coxa; ventrite 4 is also coarsely punctate, but less densely so than

3 ; 5 and 6 sometimes bear a single transverse row of punctures ; 5-7 have the anterior margin only shallowly sinuate and without a fringe of hairs, the sinuation not being angulated laterally. The hind femora bear a dark patch in the middle, the tibiae are all darker on the basal half, and the hind pair in the ♂ have the uncus normal.

*Genitalia* of ♂: the median lobe (fig. 10, b) with the sides straight and very gradually diverging from the base to beyond the middle, then gently rounded to the apex, which is broadly truncate and a little wider than the base, the lateral angles of which are obtuse, the greatest width at one-fourth from the apex ; the heavy chitinisation is confined to the lateral margins and a slightly narrower transverse band close to the apex, the rest being almost hyaline ; the median struts slender, half as long again as the median lobe, gently sinuous throughout, distinctly uniting with the sides of the lobe, and the connecting membrane between them at the base hardly chitinised ; the uneveted sac extending inwards for only one-fourth the length of the struts and without apparent asperities, the transfer-apparatus rather large and with two awl-shaped processes ; the tegmen (fig. 11, b) with the proportionate lengths of the strut, ring and dorsal lobes approximately as 3 : 2 : 4, the lobes being united only at their extreme base ; the spiculum as wide as the tegminal strut and only slightly widened at the apex, with one arm of the basal fork about half as long as the other and forming an obtuse angle with it.

*Genitalia* of ♀: the spermatheca as shown (fig. 7, c).

Length, 4.4-6 mm. ; breadth, 2-2.75 mm.

UNITED PROVINCES: Lachiwala, Dehra Dun, bred from *Mallotus philippensis*, x. 1914 (C. F. C. Beeson).

Described from 12 specimens.

**Rhadinomerus subfasciatus, sp. nov.**

♂ ♀.—Colour piceous black, with the apex of the rostrum and tarsi paler ; the extreme base of the rostrum densely, the forehead less closely, clothed with cinnamon scales ; the apical area of the prothorax with similar elongate scales, the remainder not squamose, but with erect, compressed dark setae ; the elytra variegated with more or less confluent spots of cinnamon-coloured scaling, which usually form a broad, broken transverse band behind the middle, the dark areas thinly clothed with much smaller dark scales ; the lower surface without true scaling, but with sparse erect pale setae.

The other external characters as described for *R. diversipes*, except the following : *Scutellum* of similar shape, but quite devoid of hairs. *Elytra* with the setae a little longer and distinctly narrower ; the punctures not covered by a scale, this being replaced by a very minute seta. *Legs* with the scales distinctly darker and smaller on the basal than on the apical half of the tibiae ; the hind femora with a dark median patch ; the uncus of the hind tibiae of the male normal. *Abdomen* with ventrite 3 (1st visible) much more closely punctate, the punctures being three deep behind the coxae ; ventrite 4 also bearing strong punctures, but much smaller and more widely spaced than those on 3, and less numerous in the ♀ than in the ♂.

*Genitalia* of ♂: the median lobe (fig. 10, d) shaped just like that of *R. malloti*, but the chitinised lateral areas more produced inwards in the middle, so that the hyaline median area is shaped like an hour-glass ; the median struts slender, three-fourths longer than the lobe, strongly bisinuous in the basal third, distinctly uniting with the sides of the lobe, and connected together by a lightly chitinised membrane in the basal fifth ; the uneveted sac extending inwards for nearly half the length of the struts, set with asperities in the terminal area, but without any obvious transfer-apparatus or other chitinous structure ; the tegmen (fig. 11, d,) with the

proportionate lengths of the strut, ring and dorsal lobes as 3·5 : 2 : 3, the lobes fused together for nearly half their length; the spiculum similar to that of *R. malloti*, but the fork forming almost a right angle. *Genitalia* of ♀: the spermatheca as shown (fig. 7, b).

*Length*, 3·5–4 mm.; *breadth*, 1·5–2 mm.

UNITED PROVINCES: Jhabberkhet, Dehra Dun, bred from log of *Shorea robusta*, vi.1916 (C. F. C. Beeson—type); Kotdwara, Lansdowne Division, bred from *Shorea*, ix.1917. PUNJAB: Thano, Siwalik Hills, bred from *Eugenia*, vi.1918 (Beeson).

The three previously described Indian species of *Rhadinomerus* (Faust, Ann. Mus. Civ. Genova, xxxiv 1894 (1895), pp. 279–281) are known to me from description only. *R. granicollis* is distinguished from all the species here described by its granulato-punctate prothorax and the elytra bear spatulate suberect setae. *R. conciliatus* is characterised by its cylindrical elytra, the intervals of which bear minute granules and erect hairlike setae, the prothorax being oblong and parallel-sided. The most distinctive features of *R. contemptus* appear to be that the prothorax is roundly dilated before the middle and that it is densely squamose both at the sides and at the apex.

**Rhadinopus buteae**, sp. nov. (fig. 12).

♂ ♀.—Colour black or red-brown, with dense, pale brown scaling and very broad erect scale-like setae; the pronotum with an indefinite blackish patch on each side of the middle line near the base and a few white setae in the middle of the disk; the elytra each with an ill-defined oblique whitish band running from about the middle of the suture towards the shoulder, but terminating on interval 5, and just behind this on interval 2 an elongate patch of dense erect blackish setae; the lower surface rather thinly clothed with obliquely raised broad pale scales.



Fig. 12. *Rhadinopus buteae*, sp. n.

*Head* closely punctate on the vertex, each puncture containing a minute seta; the forehead not impressed, more coarsely punctate and with dense scales, which are recumbent behind and erect in front, the interocular space parallel-sided. *Rostrum*

rather strongly curved, strongly punctate at the base, and there rather more squamose and with the median carina a little more prominent in the ♂; the antennal insertion at (♀) or a little beyond the middle (♂). *Antennae* with joint 2 of the funicle a little longer than 1, the remainder progressively diminishing and all longer than broad except 7, which is as long as broad and bead-like; the club very elongate, as long as the  $5\frac{1}{2}$  preceding joints, cigar-shaped. *Prothorax* broadest at the base, the sides gently rounded, not constricted at the apex; the dorsum strongly and closely punctate, without any median carina, the spaces between the punctures flat, shiny and impunctate; the scales large and subcircular, but scarcely overlapping, those in the middle of the disk smaller and exposing more of the integument; the very broad, erect spatulate setae truncate at the apex. *Scutellum* almost circular, slightly convex and densely clothed with small scales. *Elytra* ovate, broadest at the shoulders, which form a rounded, obtuse angle, and scarcely impressed before the apex; the comparatively small punctures almost hidden by the dense scaling, each one being covered by a large scale and set in shallow striae; the intervals a little broader than the striae, not carinate on the disk, but rather convex and somewhat rugulose or subgranulate, especially towards the base, only interval 9 carinate in the posterior half; the scales closely overlapping, and each interval with a row of very stout, erect, scale-like setae, these being more numerous on intervals 2, 3 and 5. *Legs* with uniform pale brown scaling and recumbent setae, the latter being erect only along the dorsal edge of the tibiae; the dorsal edge of the femora straight and the inferior tooth small; the tibiae markedly narrowed from base to apex, and with no angulation externally at the apex.

*Length*, 6 mm.; *breadth*, 3 mm.

PUNJAB: Rani Range, Siwalik Hills, bred from logs of *Butea frondosa*, iv. 1918 (C. F. C. Beeson).

Described from 8 specimens.

In the ♂ the last visible ventrite has a shallow impression at the apex, with a small tubercle on each side of it bearing a single seta; in the ♀ this ventrite bears a shallow transverse impression at a little distance from the apex.

From the three previously described Indian species of the genus, *centriniformis*, *consputus* and *parcus* (Faust, Ann. Mus. Civ. Genova, xxxiv, 1894 (1895), pp. 289-90) the present species may be distinguished by the common pale V-shaped mark on the elytra and by its tapering tibiae. *R. centriniformis* and *consputus* also differ, *inter alia*, in having all the setae recumbent, interval 3 on the elytra strongly carinate on the declivity, the dorsal edge of the posterior pairs of femora markedly sinuate, the seventh ventrite (last visible) of the ♂ without tubercles, tergite 7 of the ♂ almost truncate at the apex and 8 densely squamose (in *buteae* 7 of the ♂ is deeply sinuate at the apex and 8 is bare and shiny). *R. parcus* differs in having the pronotum granulato-punctate, the scutellum is punctiform and shiny, the punctures on the elytra bear only a fine seta instead of a broad scale, and the intervals are narrowly carinate.

In this genus the stridulatory apparatus of the ♂ consists of the usual files towards the apex of the elytra near the suture, the scraper being formed by two very minute, short transverse carinae on the apical edge of the seventh tergite, which are very easily overlooked. In the ♀ the files are on the seventh tergite, instead of on the elytra, and are composed of comparatively widely separated longitudinal striae, the ridges between them being very finely and transversely striate. The apparatus in both sexes is similar to that found in the European *Cryptorrhynchus lapathi*; the statement made by Dr. C. J. Gahan (Trans. Ent. Soc. Lond. 1900, p. 450) and repeated by myself (Fn. Brit. India, Curculionidae, i, p. 17), that there are no stridulatory organs in the ♀ of this species is erroneous.

## Subfamily ZYGOPINAE.

***Osphilia odinae*, sp. nov. (fig. 13).**

♂ ♀.—Colour piceous brown, rather thinly clothed above with pale hair-like scales, asymmetrically variegated with subdenuded patches; the lower surface densely covered with white scales, mostly linear, but some ovate; the base of the rostrum and a broad stripe below each eye with dense, narrow, whitish scales. The pronotum with pale yellowish scales, all of which are linear except a single row along the extreme base, which are rather shorter and broader; a broad median denuded stripe, and on each side of it a shorter oblong one narrowly uniting with it not far from the apex, thus forming (very roughly) an inverted trident, externally to which is a very indefinite lateral longitudinal sub-denuded patch; these darker areas thinly clothed with dark recumbent setae. The elytra with the following similar ill-defined and rather variable darker patches: a rounded one on the shoulder, a transverse band before the middle extending from stria 2 nearly to the lateral margin, a broad and very irregular macular transverse band behind the middle, and a rounded juxta-apical spot.

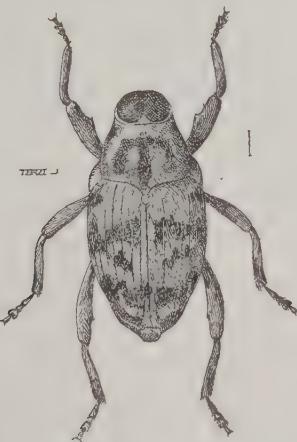


Fig. 13. *Osphilia odinae*, sp. n.

*Rostrum* as long as the head and prothorax together, entirely red-brown, gradually narrowed from the base to near the apex and thence slightly dilated, the extreme base triangular in section with the apex uppermost; the basal portion coarsely punctate (less so in ♀), but the median line smooth throughout, the punctures on the apical portion very fine and separated in ♀, and longitudinally confluent in ♂; the antennal insertion behind the middle in ♀, at or beyond it in ♂. *Antennae* of ♀ testaceous with only the club blackish, in the ♂ the whole funicle also blackish except joint 1 and the basal half of 2; the funicle with joint 2 as long as or a little longer than 1, the remainder slightly and progressively shortening outwards in the ♀, all longer than broad, except 7, which is as broad as long; in the ♂ joint 2 is strongly clavate, the dilatation being greater on the inner side, which is densely clothed with setae, the remaining joints bead-like and more nearly equal in length than in the ♀; the first joint of the club longer than broad in both sexes. *Prothorax* transverse, the sides gently rounded, broadest before the middle, the base deeply bisinuate;

the dorsal outline almost flat, the dorsum finely but confluent granulato-punctate throughout. *Scutellum* circular, densely clothed with woolly scales having their apices directed forwards. *Elytra* with the intervals broader than the very shallowly punctate striae and finely rugulose; the pale scales very long and narrow, except on the basal half of interval 1, where they are much shorter and broader and pubescent or densely fringed; the scales on the darker areas short, setiform and dark. *Legs* finely rugulose, rather thinly and uniformly clothed with long, narrow, pale scales; the front femora with a long sharp tooth, followed by a low carina bearing a single row of 9 or 10 stiff erect bristles.

*Length*, 3.25-3.5 mm.; *breadth*, 1.6-1.8 mm.

UNITED PROVINCES: Banki, Gorakhpur, bred from *Odina wodier*, v.1918 (C. F. C. Beeson—type); Chauk, Gorakhpur, bred from *Cassia fistula*, v.1918 (Beeson); Dehra Dun, bred from *Odina wodier*, v.1919 (B. B. Osmaston).

Described from 17 specimens.

Only two other species of the genus have been described from the Indian sub-region. *O. brevirostris*, Heller, from Ceylon, is of the same size, but has the rostrum only as long as the prothorax, the joints of the funicle gradually widening outwards, the antennal club pale and with the first joint broader than long, and the elytra clothed with yellow scales and with a white spot at the apex of the suture.

*O. egregia*, Fst., from Burma, is a much larger insect (6 mm.) with mottled umber and ochraceous scaling on the elytra, and three transverse rows of pale spots on the pronotum.

INSECT PESTS OF VARIOUS MINOR CROPS AND FRUIT TREES IN  
MAURITIUS.

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The following paper deals with insect pests of various minor crops and fruit trees in the Colony of Mauritius. The damage caused by most of the pests dealt with is often not very apparent, as many of these crops are not grown extensively, and have not been the object of any special investigation up to the present. If extensive cultivation of any of these should be undertaken, it is clear that there might be created a new environment favourable to increase of the insects, and that the pest problem would then have to be dealt with seriously. Our knowledge of these pests is very deficient, as their life-history and habits have never been studied in detail locally. It is also quite probable that extended cultivation may bring to light many potential pests which at present escape our attention.

The crops dealt with in this paper are all capable of being developed in the future and, for the present, nothing more than a mere enumeration of the pests for which they serve as hosts can be made, except in a few particular cases. These brief notes should only be considered as a preliminary study which will serve as a guide, as well as a warning, to those who are likely to give more extensive attention to these economic plants.

**Cotton.**

The cotton occurring in the Colony consists merely of a few plants scattered over the island. In former years, as far back as 1847, the plant used to thrive in many localities, where its cultivation was carried out on a moderate scale. The yield and quality of the cotton were good, and no trouble due to insect attack seems to have been experienced. Attempts to grow cotton on a large scale were made in 1911, but owing to various unfavourable conditions, such as bad weather, drought, scarcity of labour, and insect attacks, the enterprise did not succeed.

The Department of Agriculture, which did not exist then, is now taking up the matter, and it is hoped that a certain extension will be given to cotton growing.

The enemies of cotton are mainly cosmopolitan, and most of the chief cotton pests that have been recorded in other parts of the world occur here; the following have so far been noticed:—

*Prodenia litura*, F., and *Spodoptera mauritia*, Boisd. These two species of cut-worms, though not true cotton pests, are nevertheless polyphagous, and therefore likely to prove injurious to cotton. *Prodenia litura* is the commoner of the two, and proves quite troublesome to garden plants during the hot season. The eggs of this moth are parasitised by a species of *Telenomus*; the development of the parasite in the egg of the moth takes 21 days, and the proportion of males to females emerging from the eggs is, on an average, 1 to 3.

*Cosmophila flava*, F. (*xanthindyma*, Boisd.). The caterpillar feeds on the leaves of cotton.

*Chloridea obsoleta*, F. This polyphagous insect of world-wide distribution, commonly known as the American bollworm, is found here on a great variety of plants, the chief being maize, tobacco, *Hibiscus esculentus*, *Cajanus indicus*, and various other leguminous plants. It is also a serious pest of pelargoniums, destroying the tender stems and flowers.

*Earias insulana*, Boisd. The caterpillar is the spotted bollworm of India. It is another cosmopolitan species, and its feeding habits in Mauritius appear to be much the same as those of *Chloridea obsoleta*. It seems, however, to confine its attacks particularly to Malvaceae, and is of rather common occurrence. Twigs, leaves and flower-buds are attacked as well as the bolls.

*Platyedra gossypiella*, Snd. The pink bollworm is one of the most serious pests of cotton, and although it has not yet been observed on cotton in Mauritius, a few moths have been bred from pods of *Cajanus indicus* and other Leguminosae of the same type.

*Pyroderces (Anatrachyntis) simplex*, Wlsm. The moth has been obtained from larvae found in cotton bolls.

*Dysdercus* spp. Of the cotton pests which are found here, the red cotton-stainers, of which two species exist, are by far the most common, and are found on all malvaceous plants, as well as on many others, growing along the coast. As cotton-stainers have done considerable damage in cotton-growing centres, they can probably be looked upon as our most serious potential pest. *Dysdercus* is known to transmit several bacterial diseases. It has already done a good deal of damage to cotton bolls at the experimental plantation of the Department, and is the vector of an internal disease of the bolls similar to that described by Nowell and others in the West Indies.

*Aphis gossypii*, Glov. This green aphid is common on various garden plants as well as on cotton. It is parasitised by a species of *Aphidius*, and is preyed upon chiefly by a large ladybird, *Chilomenes lunata*, and by Syrphid flies.

*Saissetia nigra*, Nietn., and *Saissetia hemisphaerica*, Targ. These two scale-insects occur on various plants besides cotton. *S. nigra* is found chiefly on *Hibiscus esculentus*, rubber, mango and various Malvaceae. It is parasitised by two species of Chalcids and by a fungus. These probably keep it in check, as it cannot so far be reckoned as a pest. *S. hemisphaerica* occurs chiefly on citrus, guava (*Psidium*), litchi (*Nephelium*) and *Aristolochia acuminata*.

*Achatina fulica*. Though not an insect pest, mention may be made of this large snail, locally known as "Couroupa," which also occurs in India and Ceylon, whence it has been introduced here. It was responsible for a good deal of damage to cotton seedlings, when the attempt was made to plant cotton on a large scale in 1911. As the snails are very large, it is not difficult to have the land cleared of them by hand-picking before planting. This should be done in the evening, as the snail has nocturnal habits. Those met with in the daytime are generally found hiding in dark places, or are in copulation. They are most active after the first rains have set in and after sunset.

### Tobacco.

Extensive cultivation of tobacco has recently been tried by this Department, and as the results obtained have been very satisfactory, it is thought that tobacco growing may rank among the chief of our minor industries. The variety tried is that which is extensively grown in the island of Réunion. The yields have been satisfactory, and the prepared cigarette tobacco has sold rapidly. Planting is being encouraged by the Department of Agriculture, which is doing everything it can in order that tobacco cultivation may be carried out on a large scale.

Although the insects attacking this plant are not numerous, it is nevertheless useful to record them.

*Prodenia litura*, F., and *Spodoptera mauritia*, Boisd. The habits of these caterpillars have already been mentioned under cotton. The damage done to tobacco seedlings may be very great.

*Coelonia (Sphinx) solani*, Boisd. A minor pest.

*Phytometra (Plusia) orichalcea*, F., and *P. chalcytes*, Esp. These two polyphagous insects feed occasionally on tobacco. A certain amount of damage is caused to seedlings.

*Chloridea obsoleta*, F. This moth is here the chief pest. The caterpillars eat into the seed-capsules and often cause great damage ; they are also found on the leaves.

*Thrips* sp. Thrips are occasionally found in tobacco flowers, but do no great harm.

*Heterodera radicicola*. The roots are sometimes so badly infested with eelworms as to cause the death of a good many plants.

### Maize.

Maize is another important food crop and its cultivation is being extended yearly, there being now over 5,000 acres under this crop. Though the list of pests is not long, appreciable damage is caused, especially to the cobs and seedlings.

*Prodenia litura*, F., and *Spodoptera mauritia*, Boisd. These two cutworms damage the seedlings and are occasionally found on the leaves of the mature plant.

*Sesamia vutaria*, Stoll. Seedlings are badly attacked by the caterpillars of this moth. Its life-history and habits have been worked out and published in a Bulletin on Moth Borers of the Sugar-Cane (Scientific Series, Bulletin No. 5), issued by this Department. Though *Sesamia* is a regular pest of sugar-cane, the moth has a marked preference for maize seedlings, on which it deposits its eggs. As many as three or four egg-batches are inserted between the leaf-sheaths and the stem ; these are composed of 15 to 75 eggs. The young larvae tunnel into the stem of the young plant, which soon withers, and the caterpillars then migrate to older plants, in which the rest of their development is passed, the caterpillar sometimes pupating in the stem of the plant.

To gain an idea of the intensity of these attacks, the following is worth noting. In March 1915, 35 acres of maize were planted on an estate, but so many of the plants were destroyed that the yield amounted to that usually obtained from  $1\frac{1}{4}$  acres. On another occasion about 800 yards between lines of canes were planted with maize ; the plants were examined every day, and showed the following infestation :—

1st day of examination, 90 plants infested and uprooted.					
2nd	"	"	101	"	"
3rd	"	"	88	"	"
4th	"	"	64	"	"
5th	"	"	164	"	"
6th	"	"	160	"	"
7th	"	"	111	"	"
8th	"	"	120	"	"
9th	"	"	404	"	"
10th	"	"	1,925	"	"
11th	"	"	1,200	"	"
12th	"	"	1,200	"	"
Total		5,627 plants.			

It will be seen from this that *Sesamia* is a very serious pest. In addition to boring the stems it also attacks the cobs. The natural enemies of this moth are four in number. *Telenomus* sp. is an egg parasite, which has already been mentioned under *Prodenia*. The life-cycle in the egg of *Sesamia* is the same as in that of *Prodenia*. *Trichogramma australicum*, Gir., is another egg parasite. *Henicospilus antanarius*, Morl., and *Stauropodoctonus mauritii*, Morl., are both parasitic upon the full-grown caterpillar.

*Proceras (Diatraea) sacchariphaga*, Boisd., is less common than the former and attacks the plant in the same way.

*Aphis maidis*, Fitch, is sometimes common on the leaves, but is not a regular pest.

*Chloridea obsoleta*, F. The caterpillar is often found attacking the tender top part of the stem and also the young ears. It frequently feeds on the silks, sometimes destroying them entirely, in which case the ears become barren, and also bores its way into the cob after having fed on the young grain. Many ears are spoiled in this way.

When maize ears are allowed to remain on the plant until the latter has dried up, the grain is invariably attacked by weevils, *Calandra oryzae*, L., being the chief pest. Damage is also done by *Dinoderus minutus*, F. Over 50 per cent. of the grain may be destroyed before storage. These pests, as well as a Tineid moth, also cause serious damage to stored maize if fumigation is not resorted to. Full details concerning these insects will be found in Bulletin No. 2 of this Department's Scientific Series (Insects Injurious to Stored Grains in Mauritius).

#### **Manioc (Manihot utilissima).**

Manioc is another important foodstuff, being largely used for stock. The plant thrives in the hot districts, and gives very good returns. A great many varieties, most of them imported lately by the Department of Agriculture, are grown. There are practically no insect pests of the plant.

*Lachnostenra (Phytalus) smithi*, Arrow, is an occasional pest in the infested regions.

*Saissetia hemisphaerica*, Targ., is sometimes found on the leaves, but is a minor pest. A species of *Chionaspis* occurs frequently on the stem.

#### **Sweet Potato (*Ipomoea batatas*).**

This tuber is greatly in favour with the poorer classes of the population, and is also an important cattle food. The plant grows well all over the island, the highest yields being obtained in the hotter lowland regions. A great number of varieties are grown, most of which have been imported lately by the Department of Agriculture.

The chief pest of the foliage is a Pterophorid moth, *Trichoptilus wahlbergi*, Z., the larva of which feeds on the leaves, especially the tender parts and buds, and rolls up in the leaf before pupating.

*Ercta ornatalis*, Dup. This Pyralid moth is another leaf pest.

*Herse (Sphinx) convolvuli*, L. The caterpillar is occasionally found on the sweet potato, but cannot be regarded as a pest.

*Aspidomorpha obovata*, Klug. This Chrysomelid beetle is also an occasional pest, doing no great damage. It lives on various wild species of *Ipomoea*.

*Cylas formicarius*, F., is by far the worst pest. It is exceedingly common whenever sweet potatoes are grown in mounds, and is then responsible for very serious damage. As many as 50 to 100 larvae may be found in a single tuber. The method of planting sweet potatoes in mounds has only recently been adopted, and the resulting looseness of the soil certainly renders the plants more liable to the attacks of this beetle.

**Ambrevades** (*Cajanus indicus*).

This plant suffers a great deal from caterpillars, which live in the pods. In certain regions 75 per cent. of the crop is lost. Control measures are difficult to apply, for reasons mentioned further on.

*Adoretus versutus*, Har. This beetle, which has polyphagous habits, feeds on the leaves of the pigeon-pea, but is not a serious pest.

*Lachnostenra (Phytalus) smithi*, Arrow. Plants grown in the infested region are usually visited by *L. smithi*. The damage caused is insignificant, as the plants in the infested areas serve as trap plants, from which the beetles are hand-picked at night.

*Icerya seychellarum*, Westw., is common enough on almost all the plants of the island, and is only a minor pest of pigeon-pea. Various insecticides in the form of emulsions have been tried against this pest, but the results have never been successful.

*Eucalymnatus tessellatus*, Sign., is a minor pest of the twigs and attacks various other Leguminosae.

*Chionaspis subcorticalis*, Green, is occasionally found on the branches of this plant, more especially on the tender twigs, but does not do much harm.

A species of *Botys* is very common on the tender leaves.

By far the worst pests of *Cajanus indicus* are certain Lycaenid butterflies, which are exceedingly common when the plant begins to flower. The eggs are laid on the flower-buds and young pods, and the newly-hatched caterpillar, after having fed for a short time on the surface of the buds and pods, bores its way in. Advantage was taken of this to try to control the insect by spraying the flower-buds and pods with arsenate of lead. The results were not successful, for it was difficult to make the spray adhere to the flower-buds, as these are covered with fine hairs, which will not hold the spray. Moreover, at this time of the year the wind is usually very strong, so that the sprayed material is shaken off the plant before it has time to dry, in spite of its adhering power having been increased by the addition of mucilaginous substances, such as a maceration of *Opuntia* in water. The following is a list of the Lycaenids that feed in the flower-buds and pods:—*Lampides boetica*, L., *Zizera lysimoni*, Hb., *Tarucus telicanus*, Lang, and *Nacaduba mandersi*, H.H.D. Of these *Lampides boetica* is the worst pod pest, the others confining their attacks rather to the flower-buds.

*Chloridea obsoleta*, F., is an occasional pest of pods.

*Platyedra gossypiella*, Snd., is also occasionally found in pods and is more common than *Chloridea*.

*Botys* spp. Two species of PYRALIDAE are found in the flower-buds, and more rarely in the pods. These are the most dangerous pests of flower-buds, and are responsible for a great deal of damage.

**Pois Sabre** (*Canavalia ensiformis*).

Only a few pests are worth recording:—

*Thrips* are often abundant in the flowers and cause many of these to fall off.

*Argyroploce rhynchias*, Meyr. The caterpillar feeds in the pods, also attacking the twigs, and may sometimes ruin the whole crop.

*Aspidirotus* sp. This scale is a minor pest, and is found on the twigs.

*Rhopalocampta forestan*, Cram., is also a minor leaf pest.

**Voheme (Vigna catjang) and Haricot Bean (Phaseolus vulgaris).**

*Agromyza phaseoli*, Coq., is such a regular pest of these plants that their cultivation is almost impossible in certain localities and at certain times of the year.

*Remigia (Pelamia) refanda*, F. The caterpillar feeds on the leaves of *Vigna catjang*.

**Pea (Pisum sativum).**

*Plusia orichalcea*, F. The caterpillar is a minor pest of peas, doing some injury to the leaves.

*Chloridea obsoleta*, F., occurs as a leaf pest.

All the Lycaenid butterflies mentioned under *Cajanus indicus* attack the pea more or less. The chief pest, however, is *Lampides boetica*, L., which is sometimes responsible for great damage.

**Pistache (Arachis hypogaea).**

The pests attacking ground-nuts are not numerous and do not cause very serious damage.

*Chloridea obsoleta*, F., and *Plusia orichalcea*, F., are the only two worth recording as leaf pests. *Ephestia cautella*, Walk., attacks the fruits, and *Pseudococcus calceolariae*, Mask., is sometimes a serious pest of the roots.

**Pumpkins, Melons, Cucumbers, etc.**

Cucurbitaceous plants suffer severely from the attacks of the fruit-flies, *Dacus sygnoides*, Coq., and *Tridacus d'emmerezi*, Bezzi.

The caterpillar of a Pyralid moth, *Glyphodes indica*, Snd., feeds on the tender leaves and buds. It is not greatly harmful to the plant itself, but as the leaves are useful for human consumption, and as the caterpillars always roll themselves in the leaves, they are troublesome pests.

*Aphis gossypii*, Glov., is a minor pest.

**Cruciferae (Cabbage, Cauliflower, etc.).**

The Pyralid moth, *Crocidolomia binotalis*, Z., has proved to be a regular pest of cabbage. The leaves are so badly eaten that they rot *in situ* and are thus rendered unfit for human consumption.

*Plutella maculipennis*, Curt. Late in the season the leaves of cauliflowers and cabbages are badly attacked by this pest.

*Aphis brassicae*, L., occurs in abundance at the beginning of the season. Towards the end its numbers are reduced, as it is preyed upon by Syrphid flies, chiefly *Xanthogramma pfeifferi*, larvae of lace-wing flies, and by a large ladybird, *Chilomenes lunata*.

**Artichoke.**

Two pests occur:—The artichoke moth, *Porpe bjerckandrella*, Thunb., which is very prevalent at times and greatly injures the foliage; and an Aphid, *Macrosiphum picridis*, F., which is exceedingly common on the leaves and tender parts of the stem, doing serious damage.

**Tomato.**

The insect enemies of the tomato are the same as those of tobacco and need not be mentioned again. It is worth recording, however, that the eel-worm, *Heterodera radicicola*, is a regular pest and sometimes occasions great losses.

### Coconut.

This plant thrives in the coastal regions wherever the land is not rocky. A certain amount of extension is being given to its cultivation in certain parts of the coastal belt, and promising results are being obtained.

The beetle, *Oryctes tarandus*, Oliv., occasionally bores into the tender part of the stem, which it usually enters beneath the basal part of a leaf, just where it begins to stretch away from the stem, and bores a gallery right through. It also bores its way into the mid-rib of the leaf. The galleries in the stem are usually made tangentially, and in such cases, though the tree is not immediately affected thereby, a door is opened for bud-rot. It often happens, however, that the beetle bores its way radially inwards into the growing point; in such a case the health of the palm is affected and immediate death results.

Of all the scales which are found on the coconut palm, the most common is *Diaspis boisduvali*, Sign. It occurs in very great numbers all over the island and is a serious pest. The injury done is very great both to old and young plants, the insect occurring in thousands on a single leaf. Now that a certain extension is being given to the cultivation of the coconut, combative measures will have to be adopted, as the pest is a serious menace to the future of the coconut industry.

### Coffee.

Coffee was extensively grown years ago, but its cultivation has had to be abandoned on account of the attacks of leaf disease (*Hemileia vastatrix*). It is, however, cultivated in certain localities for local consumption. Liberian coffee thrives in the colder districts and yields heavily, and if its cultivation is extended good results may be expected, as it is very slightly subject to attacks of *Hemileia*.

*Cratopus punctum*, Boh. Arabian coffee does not suffer much from the attacks of this weevil, which has a marked preference for the Liberian variety, the leaves of which it devours to such an extent as to cause almost entire defoliation of the plant. It is worth noting that in the upland regions the attacks of *Cratopus* are not serious.

*Adoretus versutus*, Har., is another leaf pest.

*Botys octoguttatus*.\* The caterpillar feeds in the berry and is rather a serious pest.

*Prodenia litura*, F., destroys many seedling plants as they come up.

*Saissetia nigra*, Nietn., and *Saissetia hemisphaerica*, Targ., occur as minor pests.

*Coccus viridis*, Green, is sometimes found abundantly on the leaves of young plants in nurseries. Infestation begins as soon as the first leaves are fully developed and soon extends to the young leaves as these emerge from the bud stage. In such cases the young plants soon die. The insect also occurs in abundance on older plants, being the most important scale pest.

A small Bostrychid beetle tunnels into the twigs of the coffee plant. The galleries are bored obliquely to a length of 2 to 3 cm., reaching the pith. The attacks are sometimes so bad as to cause the drying up of the infested twigs.

### Limes and other Citrus Fruits.

The lime (*Citrus medica* var. *acida*) thrives in many parts of the island, especially in the hotter coastal regions. The crop forms the subject of a small trade on the local market, but is not of sufficient size to be dealt with on an export basis. Experimental trials are being made at present by the Department of Agriculture with a view to extending the cultivation of this plant, and it is hoped that before long lime

\* [Possibly intended for *Thliptoceras octoguttalis*, Feld.—ED.]

products will rank among the chief of our minor industries. Preserved limes are imported from Rodrigues, a dependency of Mauritius, where the trees bear good crops. The crop obtained there is, in fact, too large for the wants of the island, and the excess is salted and sent to Mauritius. Other citrus fruits, such as mandarines, oranges, lemon, shaddock, etc., also grow well and give good returns, so that on the whole the group is of increasing importance locally.

There are many insects that attack these plants, the chief pests being *Papilio demodocus* and the citrus aphis.

*Papilio demodocus*, Esp. This butterfly, which is known all over Africa as an enemy of citrus trees, is here a most troublesome pest to young plants. The caterpillar destroys the seedlings when they are three or four inches high, and if removal of the larvae from young plants is not practised constantly, considerable damage is done. No great injury is done to full-grown plants. The eggs and larvae are very conspicuous and can be easily removed from seedlings by hand-picking.

*Papilio phorbanta*, L. The life-history and habits of this butterfly are much the same as those of *Papilio demodocus*. It is less common than the latter and can rarely be reckoned as a serious pest of seedlings. The eggs are always laid on the lower surface of tender leaves; *Papilio demodocus*, on the other hand, seems to deposit its eggs anywhere.

The scale-insects found on lime trees are eleven in number and occur in abundance during the beginning of summer. When the rainy season sets in and the air becomes saturated with moisture, the scales are to a great extent attacked by several parasitic fungi, which gradually destroy them. This statement does not, however, always hold good for the coastal regions, where the heat is excessive and the climate comparatively dry. It is especially there that the presence of scale-insects is felt, for the damage caused is appreciable and the scales occur all the year round. The ten species found are:—

*Chrysomphalus aurantii*, Mask., and *Chrysomphalus ficus*, Ashm., on the twigs and stems.

*Pseudaonidia trilobitiformis*, Green, on the leaves.

*Chionaspis citri*, Comst., on the leaves and tender branches.

*Lepidosaphes gloveri*, Pack., on the leaves, tender shoots, and fruits.

*Saissetia oleae*, Bern., on the young shoots and branches.

*Saissetia hemisphaerica*, Targ., on the leaves.

*Coccus viridis*, Green, on the leaves and tender twigs. Infestation is sometimes very heavy, two to three hundred larvae and adults occurring on the same leaf. This species is heavily parasitised by two Chalcids, *Diversinervus silvestrii*, Waterst. sp. n., and *Tetrastichus sicarius*, Silv.

*Icerya seychellarum*, Westw., is a regular pest.

*Pseudococcus citri*, Risso, is a minor pest.

*Pseudococcus filamentosus*, Ckll. (*vastator*, Mask.) is commoner than the preceding species.

The buds and flowers are intensely attacked by a species of brownish-black aphis. The damage caused to the flowers is great, as a large proportion of them drop. Seedlings are sometimes infested to such an extent as to cause their growth to be stunted for a time. When such is the case, lateral growths are emitted, to the detriment of the plant.

Eggs and larvae of a Psyllid, *Trioza* sp., are found on the lower surface of the leaves at the beginning of summer. The larvae are greenish yellow and reach the adult stage in about a month. Wherever the larvae occur there is a corresponding swelling of the tissue, resembling a gall, on the upper surface of the leaf. The body of the larva fits exactly into this pseudo-gall, its dorsal part lying flush with the lower surface of the leaf. *Trioza* is not a serious local pest, though it occurs sometimes in appreciable numbers. When such is the case, the attacked leaves fall off, though not until the insects have reached the adult stage.

Mandarines suffer every year from attacks of the fruit-fly, *Ceratitis catoiri*, Guér. The only remedial measure against this pest would appear to lie in the introduction of parasites.

### Mango.

*Batocera rubus*, L. The larva of this Longicorn beetle causes appreciable damage to various trees, amongst which is the mango. In certain cases trees have been found to suffer so severely that control measures had to be adopted.

Eight to ten years ago a Cecidomyiid fly, *Procontarinia matteiana*, Kieff., found its way into the Colony. It is known to occur also in India, and was probably introduced accidentally from that country. The insect is extremely destructive, and wherever it is found the yield is reduced enormously, the leaves being infested when they are still quite tender and about 2 inches long (fig. 1). At this stage small spots



Fig. 1. Lower surface of mango leaf showing galls made by *Procontarinia matteiana*, Kieff.,

denote the places where the insect has oviposited. As the larva grows up in the leaf tissue, a gall is formed ; the one harbouring the adult insect prior to its emergence measures from 1·5 to 2·0 mm. in diameter. The gall shows equally on either surface of the leaf, but the fly emerges by puncturing the lower surface. Infestation is usually very severe, as many as 150 to 300 galls being formed on a single leaf. They occur in such large numbers that they touch one another, there being scarcely room for more. The leaves affected in this way soon dry and fall off. The life-cycle of the insect is about two months, its period of most common occurrence being from November to June inclusive.

*Coccus mangiferae*, Green, is quite common and sometimes occurs in great numbers. After the Cecidomyiid, it certainly is the worst pest of the mango leaf. The other undermentioned COCCIDAE cannot as a rule be regarded as regular pests. These are :—*Coccus hesperidum*, L., *Eucalymnatus tessellatus*, Sign., *Chionaspis dilatata*, Green, *Pseudoaonidia trilobitiformis*, Green, *Vinsonia stellifera*, Westw., and *Icerya seychellarum*, Westw. The last-named is sometimes quite common and does a certain amount of injury. As a result of the combined attacks of scale-insects, the leaves become covered with their honey secretions. On this covering there is a dense growth of sooty mould (*Capnodium* sp.), which obstructs the stomata. The leaves have a miserable appearance and cannot carry on their physiological functions as they should, so that the whole tree suffers.

The larva of the mango weevil, *Cryptorrhynchus mangiferae*, F., feeds in the stone, where it pupates. It is not a seriously destructive pest.

*Ceratitis catoiri*, Guér. A certain amount of damage is caused by the larva of this fruit-fly.

### Peaches.

*Adoretus versutus* is more or less common all over the island, and frequently attacks the leaves.

*Aulacaspis pentagona*, Targ., occurs on the stems and twigs. In the hot coastal regions this pest is the worst of those affecting this plant. It is extremely common and causes the death of a great number of trees every year.

*Cydia pomonella*, L., is another regular pest and is most harmful to peaches. On an average 75 per cent. of the fruits are infested, especially at the beginning of the ripening season.

### Banana.

Bananas are grown all over the island, and many varieties are cultivated, amongst them being the "Nain" and "Ollier." The "Gingeli" is affected with a disease of the fruit in the colder districts, but the other varieties thrive all over the country and form one of the chief food-stuffs of the poorer classes. They constitute the most popular fruit of the island, as they are cheap and procurable during most of the year.

The black banana weevil, *Cosmopolites sordidus*, Germ., is the only pest. The larvae live in the root-stock and occur sometimes in such great numbers as to cause the death of the plant. The varieties known as "Gingeli" and "Banane Carrée" are particularly affected.

THE EGG PARASITES OF THE COFFEE BUG (*ANTESTIA LINEATICOLLIS*, STAL) IN KENYA COLONY.

By F. W. DRY, M.Sc.,

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I. INTRODUCTION.

Some account of work on the egg-parasites of the coffee bug in Kenya Colony has already been published in a bulletin of the Department of Agriculture of that country.\*

When that bulletin was written the two common species of egg-parasites had not been identified, and they were consequently referred to simply as "Species A, Brown Parasite," and "Species B, Black Parasite." These two species both proved to be new and have since been described by Dodd,† "A" as *Hadronotus antestiae*, and "B" as *Telenomus truncativentris*. They may be roughly distinguished as follows:—

*Hadronotus*. Abdomen brown, head and thorax black in the female; head, thorax, and abdomen black in the male; black colour dull; antennae in both sexes of 13 segments.

*Telenomus*. Head, thorax, and abdomen bright glossy black in both sexes; abdomen of a different type from that of *Hadronotus*; antenna of the female 12-segmented and comparatively short and clubbed, antenna of the male 13-segmented, comparatively long and moniliform.

It is now possible to give some additional facts, but it should be made clear that the investigation is in a very incomplete state. This account, put together upon the present writer's ceasing to work in Kenya Colony, is a short summary of what has so far been ascertained.

II. THE LIFE-HISTORY OF THE COFFEE BUG.

A full account of the life-history of the coffee bug is given by Mr. Anderson. The following facts, the chief ones about the life-cycle that have a bearing on the relation between the bug and its egg-parasites, are taken from his bulletin.

The egg stage and all the instars of the nymphal stage were passed through considerably faster in hot than in cool weather. The length of the egg stage varied from about 9 days in the hotter months to about 13 days in the cooler ones. The average length of the nymphal stage was, for the hotter months, about 75 days, for the colder, 115 days. Combining egg and nymphal periods, the average times from egg-laying to the nymph becoming adult were respectively 84 days and 128 days. The average adult life for both sexes was a little over 100 days, but the length of life was frequently much longer, the maximum found for a female being 290 days, that for a male 249 days. The average number of eggs laid during the lifetime of a female was 126, but the number was often very much more, 485 being the highest obtained.

The egg of the coffee bug, as Mr. Anderson describes it, "is dull white in colour, covered with a fine powder which easily rubs off, leaving the egg clear and glistening. This powder appears in the form of a delicate reticulation. The egg measures roughly  $\frac{3}{4}$  mm. by 1 mm. The measurement of 100 eggs, taken at random, gave

\* Anderson, T. J.—The Coffee Bug.—B.E.A. Dept. of Agric., Div. of Ent., Bull. i, 1919.

† Dodd, A. P. Notes on the Exotic Proctotrupoidea in the British and Oxford University Museums.—Trans. Ent. Soc. Lond., Jan. 1920.

the following averages :—shorter axis 0·87 mm., longer axis 1·125 mm., the longer axis being at right angles to the point of attachment. As the embryo develops within the egg a clear ring becomes distinct on the top, marking the place where the cap will split off when the young nymph emerges. The cap is a complete arc of the egg-shell and may be completely split off or left behind, hinged on, and may shut down accurately. In some instances it fits down so tightly that only the colour shows whether the nymphs have hatched. When the egg is from four days to a week old, depending on the season, the eyes and tylus of the nymph can be distinguished as darker spots shining through the cap. The eggs are usually found in clumps of twelve, though ten and eleven are quite common. The clumps of eggs are found on the under surfaces of the leaves, occasionally on the upper surface, on the berries, on the pedicels of the berries, on the stem, on dry leaves, and even on stones beneath the bushes.” In the field 90 per cent. of the eggs collected were found on the lower side of the leaves.

### III. PARASITISED EGGS.

The female parasites have been watched vigorously prodding the coffee bug eggs with their ovipositors. The insect remains quiet for some time with the ovipositor embedded in the egg, the whole operation lasting from two to five minutes. Eggs that have been parasitised are distinguished by the fact that some time after being attacked by the parasite, this time varying with the season, the colour of the egg changes from the original dull white. Usually the eggs become bluish grey, but occasionally parasites emerge from eggs which have only become pale grey.

The parasite makes its way out of the egg through a hole with a ragged edge bitten by the insect's mandibles; the cap of a parasitised egg does not split off. Many hundreds of eggs have been kept singly in tubes in the laboratory, but never more than one parasite has been reared from one egg.

In addition to the two named species of parasites other species have been reared, but their numbers have been very few.

In collections brought in from the field the eggs were kept under observation so as to determine how many produced *Antestia*, how many had been parasitised, and how many failed both to turn blue and to produce either bug or parasite. All eggs which turned blue were recorded as parasitised, and were then kept in tubes plugged with pads of cotton wool. The parasites hatching from them were preserved and examined, and data for proportions of species and sexes are given below. Some of the eggs which turned blue did not produce parasites. Any eggs about which there was a doubt were kept until they produced parasites or until it was clear that they were not going to produce anything.

In making counts it was the practice to reject all eggs which had hatched—whether *Antestia* or parasites—before being collected, and to reject as well all clumps containing one or more eggs which had hatched before coming to hand. In this way, for each collection of eggs examined, percentages were obtained of those hatching *Antestia*, those parasitised, and those not going blue or hatching anything. The figures so calculated may be taken to represent fairly well the parasite position in the plantations where the collections were made, but the following sources of inaccuracy must be noted :—

- (a) A parasitised egg remains unhatched longer than one which produces a coffee bug.
- (b) If the eggs had not been brought into the laboratory some which hatched *Antestia* would have been parasitised in the field; this tends to counter-balance (a).
- (c) Dead eggs, white or blue, remain on the trees a long time.

In discussing the data from collections of eggs we may conveniently divide these collections into two lots:—

- A. Those from a field of coffee about six acres in extent on the Government Farm at Kabete. From this field a considerable number of collections have been made over a period of two and a half years. Particulars from these collections will be given first.
- B. Those from various other coffee plantations in the districts of Nairobi, Kyambu, Limuru and Thika, but on these plantations usually only a single collection has been made, and that generally at the time of an *Antestia* outbreak. It will not be necessary to say much about the data from these occasional collections.

#### IV. COLLECTIONS FROM GOVERNMENT FARM, KABETE.

Between July 1917 and September 1920 twenty-four collections were made from this field in as many different months. The eggs collected totalled 16,531, and the months in which they were obtained are shown in Table I.

The chief points brought to light are the following:—

The average of the monthly percentages of eggs producing *Antestia* was 15 per cent.; several times the percentage was 30 or over, while, on the other hand, of more than 5,000 eggs collected between July and October 1917 only 5 per cent. produced *Antestia*. Of the 16,531 eggs collected during the period indicated, 12,882, or 78 per cent., were parasitised, the average of the monthly percentages being practically the same as this figure, namely, 77 per cent.; the lowest monthly percentage was 54 per cent., the highest more than 90 per cent. The average monthly percentage of eggs which did not go blue and did not hatch was 8 per cent., and of those eggs which did go blue 24 per cent. did not produce parasites. Of coffee bug eggs laid in the laboratory and protected from parasites a small proportion did not hatch. Some eggs, too, exposed to parasites in the laboratory turned blue but did not produce parasites.

The causes of eggs not hatching have not been inquired into. Superparasitism and hyperparasitism, which may quite likely be connected with the failure of parasitised eggs to produce parasites, have not been investigated.

In the 9,750 parasites that were reared, the proportions of the sexes of the two species were as follows:—

	♂♂	%♂♂	♀♀	%♀♀	Total.
<i>Hadronotus</i>	1168	22.6	4009	77.4	5177
<i>Telenomus</i>	1079	23.6	3494	76.4	4573

For both species, therefore, the proportion of females to males was a little greater than 3 to 1. Figures from smaller collections from other plantations also point to a ratio of 3 or 4 to 1.

The total numbers of the two species have just been given. These give as percentages for the two species:—*Hadronotus*, 53 per cent.; *Telenomus*, 47 per cent. But it must be noted that at those periods when coffee bug eggs were most numerous *Hadronotus* usually considerably outnumbered *Telenomus*. So that, if we take the average of the quarterly percentages (see Table I) we then get:—*Hadronotus*, 43 per cent.; *Telenomus*, 57 per cent. Both these pairs of figures, however, indicate that, over a long period, the numbers of the two species in this Kabete field were fairly evenly balanced.

The variations in the frequency of the two species, for quarterly periods, are shown in Table I (p. 200). We may note:—

1. The variations are considerable; sometimes 70 per cent. or 80 per cent. were *Hadronotus*, sometimes 80 per cent. or 90 per cent. were *Telenomus*.

2. So far as the data go, the periods of ascendancy of either species lasted for from six to nine months. This time is sufficient, as the life-history figures will show, for from four to six successive generations of parasites.

3. Ascendancy of *Hadronotus* is associated with comparative abundance of coffee bug eggs. Though an accurate index of the comparative abundance of eggs was not obtained, it can be stated that they were most numerous from July to October 1917, and the period of next greatest abundance was October 1918 to March 1919. At the end of 1917 and for the first three months of 1918 they were very scarce indeed. During the remainder of the time they were moderately plentiful, though not very numerous.

#### V. COLLECTIONS FROM OTHER PLANTATIONS.

The data as yet obtained are far too few for us to be able to correlate the occurrence and subsidence of outbreaks of *Antestia* with parasite conditions, but the following points may be mentioned:—

In collections of eggs made during outbreaks of *Antestia* the percentages of normal eggs have sometimes been high and the percentages of parasitised eggs low. The following are examples:—

	Place.	Date.	Total number eggs.	Percentage producing <i>Antestia</i> .	Percentage parasitised.	Percentage not going blue and not producing anything.
1.	Near Nairobi ..	March 1918 ..	640	52	46	2
2.	Limuru .. ..	May 1918 ..	1008	58	37	5
3.	Limuru .. ..	May 1920 ..	1327	34	63	3

On the other hand, collections of eggs made during an outbreak of *Antestia* have sometimes given a low percentage of normal eggs and a high one of parasitised eggs. Such cases are:—

	Place.	Date.	Total number eggs.	Percentage producing <i>Antestia</i> .	Percentage parasitised.	Percentage not going blue and not producing anything.
4.	Kyambu .. ..	August 1917 ..	1500	6	85	9
5.	Kyambu .. ..	Sept. 1918 ..	637	7	84	9
6.	Kyambu .. ..	January 1920 ..	1191	3	87	10

The Kyambu case numbered (4) is an example of an outbreak of *Antestia* subsiding without any control measures having been taken by the planter. At the time the collection was made the bugs were extremely numerous in part of the plantation. In such cases it is usual to have the bugs collected by hand, but here, although they were left undisturbed, the following April the planter reported that the outbreak had completely subsided. This was probably due to the work of the parasites.

The Kabete field in 1917 may also be cited. In June and July the bugs were quite plentiful. In the months July to October 1917, as has already been stated

only 5 per cent. of the eggs collected produced *Antestia*, more than 85 per cent. being parasitised. Since then—up to the end of 1920—the bugs have never been at all plentiful there.

The parasites are sometimes present in force in plantations where there has never been a coffee bug outbreak. The following figures are for a field of coffee about three years old, when the collection of eggs was made where there had never been an outbreak :—

	Place.	Date.	Total number eggs.	Percentage producing <i>Antestia</i> .	Percentage parasitised.	Percentage not going blue and not producing anything.
7.	Near Nairobi	Sept. 1918	862	4	86	10

The usual state of affairs in coffee plantations, it may here be remarked, is that *Antestia* exists in small numbers only, but if the bug was present in a plantation, parasitised eggs have always been found when a search has been made for them.

There are several cases on record when one outbreak of *Antestia* that has been controlled by collecting the bugs by hand has been followed by another after some such period as two years.

From some collections, notably from the Limuru district, *Hadronotus* has been completely absent, though a very small number of *Hadronotus* have been reared from eggs from one Limuru plantation. *Telenomus* has been reared from every collection examined.

## VI. LIFE-HISTORY WORK ON THE PARASITES.

Many of the facts here given have already been published in Mr. Anderson's bulletin.

### A. *Hadronotus antestiae*.

#### (1) Length of Life of Parasites.

For parasites kept in tubes closed with a pad of dry cotton-wool, provided with water on a pad of cotton-wool moistened daily, and with coffee bug eggs in the tube, the average length of life for either sex was about six days.

Five unmated females kept singly in tubes, provided daily with diluted golden syrup on a pad of cotton-wool and supplied with coffee bug eggs, lived on the average 13 days. Further data for parasites which did not have access to coffee bug eggs have given a slightly shorter time. The longest life of a female recorded is 16 days, that of a male 13 days.

#### (2) Life-cycle of Parasites; Mated Females given Water only.

A series of experiments, in which the conditions defined below were adhered to, was designed to compare the reproductive powers of the two species. The facts for *Telenomus* will be given when the life-cycle work on that species is described.

The conditions were as follows :—(a) The experiment was set going not earlier than 22.xi.17 and not later than 21.ii.18; (b) all parasites used as parents had emerged from the coffee bug egg on the day on which the experiment was started; (c) all the parasites used were known to be virgin, as they had emerged in tubes not containing any individuals of the opposite sex; (d) the act of copulation was observed to take place; (e) once a parasite, male or female, had mated, no individual except its mate was allowed access to it during the remainder of its life; (f) the parasites were given

no food, but a pad of cotton-wool was kept moist in the glass tube, which was closed with a dry pad of cotton-wool; (g) the *Antestia* eggs used had been deposited in the laboratory, and so kept as to prevent their accidental parasitisation; (h) none of the eggs showed eye-spots when given to the parasites; (i) the number of eggs in each experiment was 50; when the experiment started eggs to this number were placed in a little cork tray having a rough floor so that the eggs would not roll about.

The results obtained from a series of ten experiments in which the above conditions were observed were as follows:—

- (a) The average lifetime of the parent parasites was 6 days, 8 days being the maximum.
- (b) On the average a little longer than 10 days elapsed before the first egg became blue, and between 13 and 14 days before the last one to become blue had changed; it will thus be noticed that the time from parasitisation of the egg to its going blue was about a third of the time from parasitisation to emergence of the parasite.
- (c) The average time between the mating of the parasites and the first hatching of their progeny was 31 days.
- (d) The total number of offspring obtained from the ten females was 233, or an average of a little over 23 per female; 256 eggs went blue, but 23 did not produce parasites; the highest number of offspring from one female was 34.
- (e) Of the 233 parasites thus obtained the numbers of the sexes were:—Male, 43; female, 190.

#### (3) Proportions of the Sexes.

At the same time as the series just described other experiments with mated females, not fed but given water, were carried out in which one or more of the conditions were not the same as those defined above. Particulars of some of these will be given directly. The times obtained were not dissimilar from those just recorded, and need not be given, but these other experiments give a larger number of parasites reared in the laboratory from mated parents from which to calculate the proportions of the sexes.

In 41 experiments, including the ten of the series just described, the numbers of the sexes were:—Male, 178; female, 696. The percentages were thus almost exactly:—Male, 20 per cent.; female, 80 per cent.

In every one of these 41 experiments the number of females exceeded the number of males. In one experiment only all the offspring, 34 in number, were female. In that experiment the parent male was the offspring of a virgin female. In six other experiments in which the parent males were bred from virgin mothers the offspring, totalling 31 males and 89 females, always included both sexes.

#### (4) One Male mating with several Females.

It was found that males will readily mate with several females. Mating, for both species of parasites, is an affair of seconds. Occasionally a male would mate twice with one female in rapid succession, but very often, and this applies also to *Telenomus*, I noticed that a female which had been mated would run away from or resist further attentions from the male.

One *Hadronotus* male, which emerged from a coffee bug egg on 30.xii.1917 and was never given food or drink, and died on 4.i.1918, mated during the course of his life with 16 virgin females. These 16 were all that were available; with the first two he mated twice, with the others once. These females were kept away from all other males for the remainder of their lives, being kept singly in tubes, provided with water, and supplied with eggs; 369 parasites were in all bred from them, 68 male, and 301 female. In every instance the number of females exceeded the number of males.

This experiment, it may be remarked, gives us the evidence of 14 cases that a single mating sufficed to produce a similar proportion of females to that found in parasites reared from eggs from the field.

(5) *Parthenogenetic Reproduction.*

In a series of 20 experiments females to which no male had ever had access were given coffee bug eggs. All the conditions defined for the series of ten mated pairs, other than those relating to mating, were observed, and the times of the life-cycle were not different from those obtained in that series. From these 20 females 442 offspring were obtained, all males; 482 eggs went blue, but 40 did not produce parasites. The largest number from one female was 40. In other experiments described under (6) and (7), in some of which the parent parasites were fed and the number of offspring was larger, all the parasites reared were males. In no single case under observation has a female been produced parthenogenetically.

(6) *Parasitisation of Eye-spotted Eggs.*

In two experiments with unmated females all the conditions of the series described above under (2) were fulfilled except one (*h*)—for all the 50 eggs, which had been laid in the laboratory and protected from parasites, showed eye-spots when they were given to the parasites. In these two experiments 28 parasites were bred, thus showing that eye-spotted eggs can be parasitised. Just how late such eggs can be successfully attacked by the parasites has not been determined.

When eggs are parasitised which do not show eye-spots, the change of colour from white to blue is fairly sudden. Often on one day such an egg will be of the typical white colour, and on the next of the typical blue. But when eye-spotted eggs are parasitised the change of colour is more gradual. After a few days—a shorter time than that in which eggs not eye-spotted would require to go blue—the colour becomes a dirty brown, which deepens with successive days. In these two experiments the eye-spots gradually faded and eventually could not be distinguished. The eggs then took on the typical blue colour, but it was not so easy as with eggs not eye-spotted to say exactly when the change took place.

(7) *Number of Eggs parasitised by fed Females, unmated.*

In each of five experiments one unmated female was given thirty different *Antestia* eggs every three days. The average number of offspring parasites, all males, obtained in these experiments was 51, the maximum being 83. These numbers are considerably higher than those obtained under the conditions of the experiments described above.

(8) *Variations in the Length of the Life-cycle.*

In hot weather the life-cycle is passed through more quickly than when it is cooler. Particulars are given in Table II (p. 201) of a series of experiments in which *Antestia* eggs, laid in the laboratory and protected from parasitisation, were placed for a short time in a tube containing numerous parasites. The minimum times for the life-cycle in the different experiments varied from 25 to 62 days. For meteorological data, see Table IV (p. 201).

It will be noticed that the time elapsing before the eggs go blue is always about a third of the period of the parasite's life-cycle within the egg.

B. *Telenomus truncativentris.*

The facts obtained in life-history work on *Telenomus* will be discussed in much the same order as for *Hadronotus*. Unless stated otherwise, the conditions in corresponding experiments on the two species were the same.

(1) *Length of Life of Parasites.*

The average length of life, for both males and females, was about 4 days when they were given water only. When fed on diluted golden syrup the average length

of life of unmated females provided with *Antestia* eggs was 22 days. Further data for fed parasites of both sexes, some with access to *Antestia* eggs, some without, have given a slightly less time. The greatest length of life of a female—one of those provided with eggs—was 51 days, that of a male 16 days.

(2) *Life-cycle of Parasites; Mated Females given Water only.*

The results of a series of ten experiments corresponding to those described for *Hadronotus* under A (2) were :—

- (a) The average lifetime of the parent parasites, as already stated, was about 4 days, 6 days being the maximum.
- (b) The first egg became blue after an average of 9 days, the last one after an average of 11 days.
- (c) As with *Hadronotus*, the time from parasitisation of the egg to its going blue was about a third of the length of the development within the coffee bug egg.
- (d) The average time between the mating of the parasites and the first hatching of their progeny was between 27 and 28 days.
- (e) The total number of offspring obtained from ten females was 75, or  $7\frac{1}{2}$  per female; 89 eggs went blue, but 14 did not produce parasites. The highest number of offspring was 12.
- (f) Of the 75 parasites thus obtained the numbers of the sexes were :—Male, 46; female, 29.

(3) *Proportion of the Sexes.*

In the series of experiments of which the results have just been given considerably more males were bred than females.

Like *Hadronotus*, *Telenomus* can reproduce parthenogenetically, all the offspring so produced also being males. In the experiments under discussion, however, the act of copulation was in every case watched. In eight of the experiments one or more females were produced; in two cases all the offspring were males, numbering 2 in one and 9 in the other. Now it has been shown that from collections of eggs from the field, for *Telenomus*, as for *Hadronotus*, the proportion of females to males is about 3 or 4 to 1. This, therefore, is the proportion of the sexes we should look for in normal bisexual breeding. We therefore want to know—and this problem has not been solved yet—why the proportion of females bred in the laboratory was lower than that of females reared from eggs from the field.

A limited number of experiments with mated females fed on dilute golden syrup were carried out, and the following short series may be taken as a hint which needs to be followed up. It so happened that three females emerged from coffee bug eggs in the presence of males about a day older than themselves. After all these parasites had been together about a day they were separated into three pairs of male and female. Each pair was put in a tube, given 30 *Antestia* eggs, and provided with dilute golden syrup until death. The act of copulation was not observed. From these three females the offspring bred were :—Male, 10; female, 40.

(4) *One Male mating with several Females.*

Males in the laboratory have mated with two, three, or four females. In no experiments were males given the opportunity to mate with any number much larger than four.

(5) *Parthenogenetic Reproduction.*

In a series of 20 experiments with unmated females the times of the life-cycle were similar to those for mated females; 159 parasites, all males, were bred from the 20 females; 196 eggs went blue, but 37 did not produce parasites; the largest number from one female was 19. In other experiments to be described under (6)

and (7), in some of which the parent parasites were fed and the number of offspring was larger, all the parasites reared were males. In no single case under observation has a female been produced parthenogenetically.

(6) *Parasitisation of Eye-spotted Eggs.*

In one experiment similar to those described under A (6) 4 male *Telenomus* were bred in eggs eye-spotted when they were offered to the parasite. The note about the change of colour of eye-spotted eggs parasitised by *Hadronotus* is applicable to those parasitised by *Telenomus*.

(7) *Number of Eggs parasitised by fed Females, unmated.*

In a series of five experiments with unmated females like those described for *Hadronotus* the average number of offspring parasites, all males, was 22, the maximum being 41. These numbers are, it will be seen, appreciably higher than those obtained when the parasites were only given water.

(8) *Variations in the Length of the Life-cycle.*

As with *Hadronotus*, the life-cycle is passed through more quickly in hotter than in cooler weather. Table III for *Telenomus* corresponds to Table II for the other species. The minimum times for the life-cycle in the different experiments varied from 46 to 21 days. Again, the eggs go blue after about a third of the period of the parasite's development within the egg has been passed through.

C. **A Comparison of the Data for *Hadronotus* and *Telenomus*.**

As has been shown, many of the facts recorded for the two species are similar. The chief differences to be noted are :—

1. In laboratory conditions, whether the parasites were fed on dilute golden syrup or only given water, *Hadronotus* produced more offspring than *Telenomus*.
2. In the offspring of *Hadronotus* mated in the laboratory there was an excess of females like that found in rearing parasites from the field. From mated *Telenomus* in laboratory conditions more males than females were generally bred.
3. For a given time of year *Telenomus* passes through its life-cycle rather more quickly than *Hadronotus*.
4. With hotter weather the life-cycle of *Hadronotus* is speeded up proportionately more than that of *Telenomus*. (Contrast Tables II and III. Temperature data are given in Table IV.)

VII. THE BEARING OF LABORATORY DATA ON FIELD DATA.

Much more laboratory work is needed to elucidate the facts from the field, but the following conclusions or suggestions may be put down.

1. On comparing the lengths of the life-cycles and the numbers of offspring per female of *Antestia* and *Hadronotus*, and *Antestia* and *Telenomus*, we see that both species of parasites have a quicker rate of reproduction than *Antestia*. But it must be borne in mind that the egg-laying powers of *Antestia* are considerable. The average number of eggs per female in the laboratory was 126. Nothing is known of the mortality of nymphal coffee bugs in field conditions, so it is clearly possible that when only some apparently small percentage—say 10 per cent.—of eggs are producing *Antestia*, the numbers of the bug may be well on the increase.

2. In the field, with both species of parasites, mating is the rule; parthenogenesis is at any rate rare.

3. Not so much light as could be desired is thrown on the problem of the vicissitudes of the two species of parasites in the Kabete field. When we find two species of parasites both attacking the same host we naturally ask why one does not succeed in crowding out the other completely. As it is very unlikely that the resultant of their reactions to the same set of conditions will be precisely the same, we are disposed to look for some condition, not always constant, which affects the two differently.

Such a condition we did find when it was learnt that the life-cycle of *Hadronotus* is speeded up more in hotter weather than that of *Telenomus*. This, however, does not give us the explanation of the facts from the Kabete field. There it appears that comparative abundance of *Antestia* eggs results in the proportion of *Hadronotus* going up, while scarcity of *Antestia* eggs would seem to send the proportion down. We may make the obvious suggestion that under natural conditions, as in the laboratory, *Hadronotus* has greater reproductive powers than *Telenomus*, but that for some reason *Telenomus* is better able than *Hadronotus* to find the eggs in times of scarcity. We need, therefore, to know much more about our two species.

With regard to the effects of temperature, reference may again be made to the almost complete absence of *Hadronotus* from the several lots of parasites reared from Limuru. The Limuru district, being higher than the Kabete field, is colder, and it may be that it is this condition that gives the advantage to *Telenomus*.

### VIII. CONCLUSION.

The facts so far ascertained have been recorded, together with some hints or suggestions, and this account will have indicated a number of points calling for further inquiry. Reference may be made to the life-history of the parasites within the coffee bug egg, to superparasitism and hyperparasitism, to the effect of laboratory conditions upon the proportions of the sexes of *Telenomus*, to the behaviour of the parasites, and to a systematic following up of the parasites in a number of plantations. These are some of the lines of work which need to be undertaken to enable us to understand the interactions between *Antestia*, *Hadronotus*, and *Telenomus*.

TABLE I.

*Collections of Coffee Bug Eggs from 6-acre Field, Government Farm, Kabete.*

PERIOD.	Months during which eggs were collected.	Total number of parasites.	<i>Hadronotus.</i>		<i>Telenomus.</i>	
			No.	%	No.	%
<i>1917.</i>						
3rd Quarter ..	July, Aug., Sept.	2557	1469	57	1088	43
4th Quarter ..	Oct. .. ..	955	627	66	328	34
<i>1918.</i>						
1st Quarter ..	.. .. ..	Eggs	very scarce.			
2nd Quarter ..	April, June ..	413	32	8	381	92
3rd Quarter ..	July, Aug., Sept. ..	771	219	28	552	72
4th Quarter ..	Oct., Nov., Dec. ..	1227	924	75	303	25
<i>1919.</i>						
1st Quarter ..	Jan., Feb., Mar. ..	1579	1167	74	412	26
2nd Quarter ..	April, May, June ..	488	412	84	76	16
3rd Quarter ..	.. .. ..	Eggs	not collected.			
4th Quarter ..	Nov. .. ..	340	153	45	187	55
<i>1920.</i>						
1st Quarter ..	Jan. .. ..	632	104	16	528	84
2nd Quarter ..	May .. ..	295	35	12	260	88
3rd Quarter ..	July, Sept. .. ..	493	35	7	458	93
Totals .. .. .. .. .. ..		9750	5177	53	4573	47
Averages of monthly percentages .. .. .. .. .. ..		..	..	43	..	57

TABLE II.  
*Variations in the Length of the Life-cycle of Hadronotus.*

<i>Antestia</i> eggs exposed to parasites.		Number of days to first eggs blue.	First parasites emerged.	Number of days to first emergence.	Number of days during which emergence continued.	Total number of parasites.
From.	To.					
11.vii.18	12.vii.18	21	11.ix.18	62	3	10
16.vii.18	17.vii.18	20	14.ix.18	60	6	18
23.vii.18	24.vii.18	19	18.ix.18	57	4	20
31.vii.18	1.viii.18	21	24.ix.18	55	7	8
4.viii.18	5.viii.18	20	24.ix.18	51	8	11
9.viii.18	10.viii.18	19	26.ix.18	48	7	8
2.ix.18	3.ix.18	13	8.x.18	36	10	18
16.x.18	17.x.18	10	18.x.18	32	3	30
19.x.18	20.x.18	10	19.x.18	30	5	30
20.xi.18	23.xii.18	8	22.i.19	33	4	23
30.i.19	2.ii.19	7	23.ii.19	24	2	28
2.ii.19	5.ii.19	7	27.ii.19	25	2	17

Particulars of the life-cycle during the months November 1917 to March 1918 are given under VI.A.

TABLE III.  
*Variations in the Length of the Life-cycle of Telenomus.*

<i>Antestia</i> eggs exposed to parasites.		Number of days to first eggs blue.	First parasites emerged.	Number of days to first emergence.	Number of days during which emergence continued.	Total number of parasites.
From.	To.					
10.vii.18	11.vii.18	13	25.viii.18	46	2	13
22.vii.18	23.vii.18	13	5.ix.18	45	4	36
23.vii.18	24.vii.18	13	5.ix.18	44	5	23
27.vii.18	28.vii.18	13	8.ix.18	43	1	9
4.viii.18	5.viii.18	13	13.ix.18	40	3	21
9.viii.18	10.viii.18	14	18.ix.18	40	2	6
13.ix.18	14.ix.18	9	11.x.18	28	2	4
19.ix.18	20.ix.18	9	18.x.18	29	1	3
17.xii.18	20.xi.18	9	16.i.19	30	3	7
25.i.19	28.i.19	8	16.ii.19	22	2	8
28.i.19	31.i.19	9	18.ii.19	21	4	6
31.i.19	3.ii.19	7	22.ii.19	22	5	8

Particulars of the life-cycle during the months November 1917 to March 1918 are given under VI.B.

TABLE IV.  
*Monthly Temperature Data, Government Farm, Kabete, 1917 to 1920.*

Month.	1917.				1918.				1919.				1920.			
	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.
Jan.	50	72	61	46	78	62	52	77	64	49	49	78	81	63	65	63
Feb.	52	73	62	48	79	63	55	78	66	49	49	72	73	64	65	63
March	51	75	63	49	80	64	55	78	66	55	55	72	73	64	65	63
April	55	71	63	54	73	63	56	74	65	56	56	73	73	59	60	59
May	53	71	62	53	70	61	54	72	63	58	58	61	61	59	60	59
June	50	68	59	52	68	60	50	70	60	51	51	65	65	58	58	59
July	47	69	58	50	68	59	50	66	58	50	50	67	67	58	58	59
Aug.	50	70	60	49	70	59	48	72	60	49	49	69	69	59	59	59
Sept.	49	73	61	49	75	62	52	74	63	47	47	73	73	60	60	60
Oct.	52	74	63	54	77	65	54	72	63	52	52	73	73	62	62	62
Nov.	51	73	62	53	73	63	52	73	62	55	55	71	71	63	63	63
Dec.	46	77	61	53	73	63	49	75	62	53	53	70	70	61	61	61



## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. BALLARD, Government Entomologist :—60 Rhynchota ; from South India.

Mr. H. A. BALLOU, Entomologist, Imperial Department of Agriculture :—11 Weevils and 8 early stages ; from Grenada.

Mr. C. F. C. BEESON, Forest Zoologist :—252 Coleoptera ; from India.

Mr. G. E. BODKIN, Government Economic Biologist :—13 Culicidae, 5 Hippoboscidae, 4 Siphonaptera, 2 Hymenoptera, 33 Coleoptera, 1 species of Coccidae, 10 other Rhynchota, 3 Orthoptera, 2 Mantispids, 5 Odonata, and 15 Mallophaga ; from British Guiana.

Mr. JOHN R. BOVELL, Superintendent of Agriculture :—1 Culicid, 4 other Diptera, 8 Chalcididae, 5 Coleoptera, 6 Lepidoptera, 37 Isoptera, 2 species of Coccidae, 4 Aphididae, and 1 Pentatomid bug ; from Barbados.

Prof. C. K. BRAIN :—34 Coleoptera, 2 Trichoptera, 7 Planipennia, and 7 Odonata ; from South Africa.

Major-General Sir DAVID BRUCE, K.C.B., F.R.S. :—100 Ants and 2 Weevils ; from Madeira.

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